PERMIT RENEWAL
for the
WASATCH REGIONAL LANDFILL
Tooele, Utah

Prepared for:

Wasatch Regional Landfill
8833 North Rowley Road
North Skull Valley, UT 84029
(801) 924-8540

Prepared by:

VECTOR ENGINEERING, INC.
An Ausenco group company
143E Spring Hill Drive
Grass Valley, CA 95945
(530) 272-2448

Project No. 061204.17
September 2009

VOLUME 2
Appendices 4.4 – 13.1

APPENDIX 4.4
Water Rights Memo

MEMORANDUM

TO: SCOTT CARLSON, PE, PLS

FROM: DOUG SCOW

SUBJECT: WATER RIGHTS REVIEW

DATE: 6/11/2003

CC: FILE

Please find attached the preliminary review (absent a site visit) for the water rights associated with the proposed site for the Tooele # 1 Municipal Landfill. I have left the report in "draft" form to allow for your comments and/or additions. Included as an appendix are copies of the official files for ease of reference. Once you have completed your review of the report and any necessary changes have been made, I'll provide you with an electronic copy so that you can incorporate the information into your final report as necessary.

If you have any questions or if you need any additional information, please let me know. I have enjoyed working with you on this aspect of your project.

DRAFT

MEMORANDUM

TO: SCOTT CARLSON, PE, PLS

FROM: WESTERN STATES WATER

SUBJECT: WATER RIGHTS – PRELIMINARY REPORT (ABSENT SITE VISIT)

DATE: 6/11/2003

CC: FILE

SECTION I

INTRODUCTION

This memorandum provides for a review of certain water rights associated with the proposed site for the Tooele #1 Municipal Landfill. There are five water rights, which have been reviewed which are located within the proposed site boundary as well as directly adjacent to the proposed site. The water rights reviewed in this report are as follows:

- Water Right 16-533
- Water Right 16-677
- Water Right 16-696
- Water Right 16-697
- Water Right 16-698

A brief review of the above-referenced water rights was conducted at the Division of Water Rights to determine the current status of the water rights based on the official file of record with the State of Utah. After locating and reviewing the files, a brief meeting was held with the Regional Engineer who has jurisdiction over the proposed site area.

After a review of the files and meeting with the Regional Engineer, it was determined that two of the water rights (16-533 and 16-677) were no longer valid due to the fact that they had both been rejected some years back and the actual hard copy files have been destroyed by the Division of Water Rights. These two water rights, for the purpose of this review will be considered null and void as they have no current standing with the State of Utah, Division of Water Rights. A detail of the valid water rights is presented in SECTION II.

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SECTION II

WATER RIGHTS

Water Right 16-696:

This water right is owned by the United State of America – Bureau of Land Management ("BLM"). The BLM maintains a 100% ownership interest in this water right. An application to appropriate water (A58905) was filed with the Utah State Engineer on June 2, 1983. Apparently all of the required information was not submitted at the time of filing. When all of the appropriate information and documentation was submitted to the State Engineer's office in its entirety, the priority date was "rolled back" to March 22, 1984, the date of the amended submittal. After the review and evaluation process, which is administered by the State Engineer's office, application A58905 was ultimately approved on August 3, 1984.

The BLM filed the application which called for the construction of a 5 foot dam to create a storage reservoir on property that they own. This storage reservoir is to collect surface runoff as a source and the reservoir is designed with a capacity of 0.1 acre-feet. The reservoir, as stated, consists of an earthen impoundment to collect the surface run-off and inundates 0.1 acres. This reservoir is to provide stockwatering for animals of BLM permitees authorized to use public lands and water and other incidental wildlife use on a year-round basis. The proposed use was specifically intended for the stockwatering of the "Lakeside Allotment" which consists of 600 head of cattle.

Water Right 16-697:

This water right is owned by the United State of America – Bureau of Land Management ("BLM"). The BLM maintains a 100% ownership interest in this water right. An application to appropriate water (A58906) was filed with the Utah State Engineer on June 2, 1983. Apparently all of the required information was not submitted at the time of filing. When all of the appropriate information and documentation was submitted to the State Engineer's office in its entirety, the priority date was "rolled back" to March 22, 1984, the date of the amended submittal. After the review and evaluation process, which is administered by the State Engineer's office, application A58906 was ultimately approved on August 3, 1984.

The BLM filed the application which called for the construction of a 6 foot dam to create a storage reservoir on property that they own. This storage reservoir is to collect surface runoff as a source and the reservoir is designed with a capacity of 0.1 acre-feet. The reservoir, as stated, consists of an earthen impoundment to collect the surface run-off and inundates 0.15 acres. This reservoir is to provide stockwatering for animals of BLM permitees authorized to use public lands and water and other incidental wildlife use on a year-round basis. The proposed use was specifically intended for the stockwatering of the "Lakeside Allotment" which consists of 600 head of cattle.

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Water Right 16-698:

This water right is owned by the United State of America – Bureau of Land Management ("BLM"). The BLM maintains a 100% ownership interest in this water right. An application to appropriate water (A58907) was filed with the Utah State Engineer on June 2, 1983. Apparently all of the required information was not submitted at the time of filing. When all of the appropriate information and documentation was submitted to the State Engineer's office in its entirety, the priority date was "rolled back" to March 22, 1984, the date of the amended submittal. After the review and evaluation process, which is administered by the State Engineer's office, application A58907 was ultimately approved on August 3, 1984.

The BLM filed the application which called for the construction of an 8 foot dam to create a storage reservoir on property that they own. This storage reservoir is to collect surface runoff as a source and the reservoir is designed with a capacity of 0.1 acre-feet. The reservoir, as stated, consists of an earthen impoundment to collect the surface run-off and inundates 0.2 acres. This reservoir is to provide stockwatering for animals of BLM permitees authorized to use public lands and water and other incidental wildlife use on a year-round basis. The proposed use was specifically intended for the stockwatering of the "Lakeside Allotment" which consists of 600 head of cattle.

A copy of the official file of record for each water right presented in this review is included in this report as Appendix A. This copy is representative of the file contents as of June 4, 2003.

SECTION III

POTENTIAL SITE IMPACT – WATER RIGHTS

Given the intended and approved uses for the above-referenced water rights, some mitigation would be a necessary component of any feasibility analysis regarding the construction of a landfill at the proposed location.

Of the three water rights that have been reviewed, two (16-696 & 16-697) are located within the proposed site boundary. The third 16-698, is located adjacent to the Southern boundary line of the proposed site. With the primary use of these water rights being stockwatering for the permitted users of the subject public land and water, additional sources and/or collection systems would need to be developed if the landfill inundated the property where the existing points of diversion for these water rights are located. This mitigation activity would need to be developed to the extent so as to provide for the same quantity of water that currently is approved for use with the corresponding storage component. The mitigation efforts would also need to be in an area that could provide for the same amount of runoff water as a source that is being captured and utilized at the current existing

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locations. It would also stand to reason that any existing permits which authorize use of the land and water would have to be reissued and relocated to another location to accommodate the grazing and required stockwatering of the Lakeside Allotment (600 head of cattle). Although water right 16-698 is located outside of the proposed site boundary, similar impacts could be realized with the construction of a landfill including displacement of land suitable for grazing and watering of livestock. This water right could also require the same type of mitigation as those water rights located directly within the proposed site boundary.

A site visit would need to be conducted to further evaluate the proposed site in terms of the water rights and any potential impact the landfill would have on impairment of the existing water rights.

Appendix A

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 06/04/2003 Page 1

RNUM: 16-533 APPLICATION/CLAIM NO.: A38841 CERT. NO.:

WNERSHIP***

AME: Gardner, Jack N. OWNER MISC:
DDR: 220 Felt Bldg.
ITY: Salt Lake City STATE: UT ZIP: 84111
AME: Stewart, Douglas D. OWNER MISC:
DDR: 220 Felt Bldg
ITY: Salt Lake City STATE: UT ZIP: 84111
AME: Stock, Eldon M. OWNER MISC:
DDR: 220 Felt Bldg.
ITY: Salt Lake City STATE: UT ZIP: 84111
AND OWNED BY APPLICANT?

ATES, ETC.***

ILING: 06/04/1968|PRIORITY: 06/04/1968|ADV BEGAN: 07/05/1968|ADV ENDED: |NEWSPAPER:
ROTST END: |PROTESTED: [Yes] |APPR/REJ: [ ] |APPR/REJ: |PROOF DUE: |EXTENSION:
LEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: |LAP, ETC: 06/22/1984|PROV LETR: |RENOVATE:
ECON REQ: |TYPE: [ ]
) Book No. Type of Right: APPL Status: REJD Source of Info: APPL Map: Date Verified: 02/27/1984 Initials: WHS

OCATION OF WATER RIGHT***

LOW: 5.0 cfs SOURCE: Underground Water Well
OUNTY: Tooele COMMON DESCRIPTION:

OINTS OF DIVERSION -- UNDERGROUND:
) N 1500 ft W 500 ft from SE cor, Sec 04, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
) S 2800 ft E 1400 ft from NW cor, Sec 10, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
) N 300 ft 0 ft from S4 cor, Sec 21, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
) N 300 ft W 300 ft from SE cor, Sec 29, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
) N 2640 ft W 2640 ft from SE cor, Sec 06, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
) N 1850 ft E 1600 ft from SW cor, Sec 08, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 109 to ft. YEAR DRILLED: WELL LOG?
Comment:
) N 750 ft W 2000 ft from SE cor, Sec 17, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?

Comment:
(8) S 2000 ft E 2400 ft from NW cor, Sec 17, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(9) S 1800 ft W 900 ft from NE cor, Sec 20, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(10) N 2600 ft W 2800 ft from SE cor, Sec 28, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(11) S 2800 ft W 1500 ft from NE cor, Sec 33, T 2N, R 8W, SLBM DIAM: ins. DEPTH: to ft. YEAR DRILLED: WELL LOG?
Comment:
(12) N 100 ft W 20 ft from SE cor, Sec 36, T 3N, R 9W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:

PLACE OF USE OF WATER RIGHT

	NORTH-WEST¼				NORTH-EAST¼				SOUTH-WEST¼				SOUTH-EAST¼			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 04 T 1N R 8W SLBM													X	X	X	X
Sec 10 T 1N R 8W SLBM									X	X	X	X				
Sec 21 T 1N R 8W SLBM													X	X	X	X
Sec 28 T 1N R 8W SLBM													X	X	X	X
Sec 29 T 1N R 8W SLBM													X	X	X	X
Sec 06 T 2N R 8W SLBM													X	X	X	X
Sec 08 T 2N R 8W SLBM									X	X	X	X				
Sec 08 T 2N R 8W SLBM					X	X	X	X								
Sec 17 T 2N R 8W SLBM	X	X	X	X									X	X	X	X
Sec 20 T 2N R 8W SLBM					X	X	X	X								
Sec 28 T 2N R 8W SLBM													X	X	X	X
Sec 33 T 2N R 8W SLBM													X	X	X	X

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 533
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###DOMESTIC: 30 Persons Diversion Limit: PERIOD OF USE: 01/01 TO 12/31

###MINING: DISTRICT: Lakeside NAME: Lost Silver Lode PERIOD OF USE: 01/01 TO 12/31
ORES: Gold, Silver, Lead, Zinc

###OTHER Processing and washing gravel.

OTHER COMMENTS

Protected by U.S. Bureau of Land Management.
Wells Nos. 1, 2, 3, and 12 will also be used for milling of ores.
This application REJECTED by Memorandum Decision dated June 22, 1984.

E N D O F D A T A

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UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 06/04/2003 Page 1

RNUM: 16-677 APPLICATION/CLAIM NO.: A58975 CERT. NO.:

NERSHIP**

AME: Delle, City of OWNER MISC: c/o Neil Ray Cornwell
DDR: 907 North 19th East
ITY: Salt Lake City STATE: UT ZIP: 84108
AND OWNED BY APPLICANT? No

TES, ETC.**

LING: 06/13/1983|PRIORITY: 06/13/1983|ADV BEGAN: 02/23/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
ROTST END:04/07/1984|PROTESTED: [No] |APPR/REJ: [ ]|APPR/REJ: |PROOF DUE: |EXTENSION:
EC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: |LAP, ETC: 07/13/1984|PROV LETR: |RENOVATE:
CON REQ: |TYPE: [ ]
Book No. Type of Right: APPL Status: REJD Source of Info: APPL Map: Date Verified: 02/27/1984 Initials: WES

CATION OF WATER RIGHT**

OW: 0.1 cfs SOURCE: Underground Water Well
UNTY: Tooele COMMON DESCRIPTION: Delle

INTS OF DIVERSION -- UNDERGROUND:
) S 550 ft E 550 ft from NW cor, Sec 05, T 1N, R 8W, SLBM DIAM: 8 ins. DEPTH: 400 to 600 ft. YEAR DRILLED: WELL LOG?
Comment:
) S 1200 ft E 100 ft from NW cor, Sec 05, T 1N, R 8W, SLBM DIAM: 8 ins. DEPTH: 400 to 600 ft. YEAR DRILLED: WELL LOG?
Comment:

ACE OF USE OF WATER RIGHT**

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
05 T 1N R 8W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

S OF WATER RIGHT**

AIMS USED FOR PURPOSE DESCRIBED: 677
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 314 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31

###DOMESTIC: 150 Family Diversion Limit: PERIOD OF USE: 01/01 TO 12/31

###MUNICIPAL: Delle City PERIOD OF USE: 01/01 TO 12/31

OTHER COMMENTS

Applicant is in process of negotiating for purchase of power Delle City Townsite.

END OF DATA

ıtah .gov Stale Online Services Agency List Search Utah.go go

TAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 06/04/2003 Page 1

RNUM: 16-696 APPLICATION/CLAIM NO.: A58905 CERT. NO.:

INERSHIP***

AME: USA Bureau of Land Management OWNER MISC:
DDR: 2370 South 2300 West
ITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%
AND OWNED BY APPLICANT? Yes

ATES, ETC.***

LING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
ROTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
EC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
CON REQ: |TYPE: [ ]
Book No. Type of Right: APPL Status: WUCS Source of Info: WUC Map: 14 Date Verified: 08/07/1989 Initials: WHS

CATION OF WATER RIGHT**

OW: 0.1 acre-feet SOURCE: Surface Runoff (Stkwtrg. Reservoir)
UNTY: Tooele COMMON DESCRIPTION: 6 miles N. of Delle

INT OF DIVERSION -- SURFACE:
) S 1500 ft W 1700 ft from NE cor, Sec 33, T 2N, R 8W, SLBM
Diverting Works: An earthen impoundment Source: Surface Runoff

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ACE OF USE OF WATER RIGHT**

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
c 33 T 2N R 8W SLBM	* : : : *	* : : X: *	* : : : *	* : : : *

ES OF WATER RIGHT**

AIMS USED FOR PURPOSE DESCRIBED: 696
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
keside Allotment

###WILDLIFE Incidental wildlife purposes.

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------------------------------------------------------------------------------------------
Storage from 01/01 to 12/31, inclusive, in Unnamed Reservoir with a maximum capacity of 0.100 acre-feet, located in:
   Height of Dam:          5   NORTH-WEST¼       NORTH-EAST¼       SOUTH-WEST¼       SOUTH-EAST¼
   Area Inundated:      0.10   NW NE SW SE       NW NE SW SE       NW NE SW SE       NW NE SW SE
Sec 33 T  2N R  8W SLBM      *  :  :  :  *     *  :  : X:  *     *  :  :  :  *     *  :  :  :  *
------------------------------------------------------------------------------------------
OTHER COMMENTS****************************************************************************
------------------------------------------------------------------------------------------
     The required information necessary to complete this application was not
     received until March 22, 1984, even though it was originally filed
     June 2, 1983.  The priority date is thus brought down to March 22, 1984.
******************************************************************************************
**************************************************E N D   O F   D A T A*******************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 06/04/2003 Page 1

RNUM: 16-697 APPLICATION/CLAIM NO.: A58906 CERT. NO.:

NERSHIP***

AME: USA Bureau of Land Management OWNER MISC:
DDR: 2370 South 2300 West
ITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%
AND OWNED BY APPLICANT? Yes

ATES, ETC.**

LING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
OTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
EC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
CON REQ: |TYPE: [ ]
Book No. Type of Right: APPL Status: WUCS Source of Info: WUC Map: 14 Date Verified: 08/07/1989 Initials: WHS

CATION OF WATER RIGHT***

OW: 0.1 acre-feet SOURCE: Surface Runoff (Stckwtrg. Reservoir
UNTY: Tooele COMMON DESCRIPTION: 6 Miles North of Delle

INT OF DIVERSION -- SURFACE:
) N 200 ft W 1300 ft from SE cor, Sec 33, T 2N, R 8W, SLBM
Diverting Works: Earthen impoundment Source: Surface runoff

ACE OF USE OF WATER RIGHT***

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
c 33 T 2N R 8W SLBM	* : : : *	* : : : *	* : : : *	* : : : X*

ES OF WATER RIGHT***

AIMS USED FOR PURPOSE DESCRIBED: 697
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Ceside Allotment

###WILDLIFE Incidental wildlife purposes.

```
--------------------------------------------------------------------------------------------------------------
Storage from 01/01 to 12/31, inclusive, in Unnamed Reservoir with a maximum capacity of 0.100 acre-feet, located in:
   Height of Dam:          6   NORTH-WEST¼       NORTH-EAST¼       SOUTH-WEST¼       SOUTH-EAST¼
   Area Inundated:      0.15   NW NE SW SE       NW NE SW SE       NW NE SW SE       NW NE SW SE
 Sec 33 T  2N R  8W SLBM       *  :  :  :  *     *  :  :  :  *     *  :  :  :  *     *  :  :  : X*
--------------------------------------------------------------------------------------------------------------
OTHER COMMENTS********************************************************************************************
--------------------------------------------------------------------------------------------------------------
     The required information necessary to complete this application was not
     received until March 22, 1984, even though it was originally filed
     June 2, 1983.  The priority date is thus brought down to March 22, 1984.
**************************************************************************************************************
*********************************************************E N D   O F   D A T A********************************
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Natural Resources | Contact | Disclaimer | Privacy Policy | Accessibility Policy

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 06/04/2003 Page 1

WRNUM: 16-698 APPLICATION/CLAIM NO.: A58907 CERT. NO.:

OWNERSHIP***

NAME: USA Bureau of Land Management OWNER MISC:
ADDR: 2370 South 2300 West
CITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%
LAND OWNED BY APPLICANT? Yes

DATES, ETC.***

FILING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
PROTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
ELEC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
RECON REQ: |TYPE: [ ]
Book No. Type of Right: APPL Status: WUCS Source of Info: WUC Map: 14 Date Verified: 08/07/1989 Initials: WHS

LOCATION OF WATER RIGHT***

FLOW: 0.1 acre-feet SOURCE: Surface Runoff (Stkwtrg. Resevoir)
COUNTY: Tooele COMMON DESCRIPTION: 5 Miles North of Delle

POINT OF DIVERSION -- SURFACE:
(1) N 4450 ft E 600 ft from SW cor, Sec 10, T 1N, R 8W, SLBM
Diverting Works: An earthen impoundment Source: Surface Runoff

PLACE OF USE OF WATER RIGHT***

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
SEC 10 T 1N R 8W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

USES OF WATER RIGHT***

CLAIMS USED FOR PURPOSE DESCRIBED: 698
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Lakeside Allotment

###WILDLIFE Incidental Wildlife purposes.

Storage from 01/01 to 12/31, inclusive, in Dead Cow Point Reservoir with a maximum capacity of 0.100 acre-feet, located in:

```
   Height of Dam:          8   NORTH-WEST¼      NORTH-EAST¼      SOUTH-WEST¼      SOUTH-EAST¼
   Area Inundated:      0.20   NW NE SW SE      NW NE SW SE      NW NE SW SE      NW NE SW SE
Sec 10 T  1N R  8W SLBM        * X:  :  :  *    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *
```

OTHER COMMENTS**

The required information necessary to complete this application was not received until March 22, 1984, even though it was originally filed June 2, 1983. The priority date is thus brought down to March 22, 1984.

****
E N D   O F   D A T A
****

IN THE DISTRICT COURT OF THE THIRD JUDICIAL DISTRICT

IN AND FOR TOOELE COUNTY, STATE OF UTAH

IN THE MATTER OF THE GENERAL DETERMINATION OF RIGHTS TO THE USE OF ALL THE WATER, BOTH SURFACE AND UNDERGROUND, WITHIN ALL OF TOOELE COUNTY; ALL OF JUAB COUNTY, EXCEPT THAT PORTION DRAINING TO UTAH LAKE AND TO THE SEVIER RIVER DRAINAGE; AND ALL OF MILLARD, BEAVER, AND IRON COUNTIES EXCEPT THAT PORTION IN THE SEVIER RIVER AND THE VIRGIN RIVER DRAINAGE IN UTAH.

RECEIVED
JUL 31 1989
WATER RIGHTS
SALT LAKE

STATEMENT OF WATER USER'S CLAIM

Water Right No. 16 - 696

Civil No. 6049

Map No. 14

HOW TO USE THIS FORM:

This form is important to you in asserting your water rights in the pending judicial adjudication described above. Under Utah law, unless you file this form in a timely manner, your water rights cannot be recognized and you may not assert them further. The State Engineer has made a hydrographic survey of this area, which includes your water rights and uses. Your receipt of this form constitutes notice to you that the survey has been completed and that a signed Statement of Water User's Claim is due from you within 90 days. Review the information shown on this form carefully. If you agree with the information and accept it as your Statement of Water User's Claim, sign the form and file it with the District Court in Tooele, Utah. Return two copies of the form to the Division of Water Rights in Salt Lake City, Utah. If you do not agree with the information, contact the Division of Water Rights in Salt Lake City, Utah, to resolve the problem.

1. WATER RIGHT AND OWNERSHIP INFORMATION:

   A. NAME: USA Bureau of Land Management — INTEREST: 100%
      ADDRESS: 2370 South 2300 West, Salt Lake City, UT 84119

   B. TYPE OF RIGHT: Application To Appropriate No. A58905, Water User's Claim

   C. PRIORITY DATE: March 22, 1984

2. SOURCE INFORMATION:

   A. QUANTITY OF WATER: 0.1 acre-feet

   B. DIRECT SOURCE: Surface Runoff (Stkwtrg. Reservoir)

   C. POINT OF DIVERSION -- SURFACE:
      (1) S 1500 feet W 1700 feet from NE corner, Section 33, T 2N, R 8W, SLBM
          DIVERTING WORKS: An earthen impoundment — SOURCE: Surface Runoff

   D. DRAINAGE AREA: Great Salt Lake Desert-South — COUNTY: Tooele

   E. STORAGE. Water is to be diverted for storage into:

6. CERTIFICATION OF CLAIM AND WAIVER OF SUMMONS:

The undersigned hereby enters their appearance in this water adjudication proceeding and hereby waives service of summons or other process and waives service of the notice of completion as required by Sections 73-4-4 and 73-3-4 of the Utah Code Annotated, 1953 as amended.

STATE OF UTAH)
) SS
COUNTY OF Salt Lake)

The undersigned swears on oath that he makes and certifies this Water User's Claim either as the claimant himself or as the duly-authorized agent of the claimant, that he has read and knows the contents of the claim, that he signs the same, and that the information supplied therein is true to the best of his knowledge and belief.

Title: District Manager (Individual or Office)   Deane H. Zeller Signature

Subscribed and sworn to before me this 26th day of July, 1989

Notary Public
TERESA L. CATLIN
2370 South 2300 West
Salt Lake City, Utah 84119
My Commission Expires
February 8, 1993
State of Utah

Commission expires: Teresa L. Catlin Notary Public

63-61 FORM 77 7/77

ELECTION RECORD SHEET

Application No. A58905 W. U. Claim No. 16-696

Name of Appropriator USDI Bureau of Land Management

Address 324 South State #301, Salt Lake City, UT 84111-2303

Date Election Submitted February 19, 1987 Proof Due Date October 31, 1987

Field Checked by BSWC Date 6/24/99

CORRECTIONS AND AMENDMENTS NEEDED FOR AN AMENDATORY CHANGE

	Name and Address	Quantity of Water	Period of Use	Point of Div.	Diversion & Carrying Works	Place of Use	Extent of Use	Suppl. Water Rights	AMENDED CHANGE	
									Date Filed	Date Approved
Field										
Office										

REMARKS:

↑N

Rough Water User's Claim Prepared ☐

Water User's Claim Typed ☐

Dates Water User Notified:

Water User's Claim Signed ☐

Application No. ________

Water User's Claim No. ________

FORM 152

RECEIVED
FEB 19 1987
WATER RIGHTS

A T T E N T I O N

THIS FORM IS TO BE USED ONLY WHEN WATER HAS BEEN PLACED TO FULL BENEFICIAL USE

BEFORE THE STATE ENGINEER OF THE STATE OF UTAH
ELECTION TO FILE WATER USER'S CLAIM

APPLICATION NO. 58905 16-696

STATE OF UTAH

COUNTY OF Tooele

USDI Bureau of Land Management, being first duly sworn, says that he is the owner of the above application; that the development contemplated under this application has been completed and the water placed to beneficial use.

In lieu of submitting "Proof of Appropriation" or "Proof of Change" and receiving "Certificate of Appropriation" or "Certificate of Change", the applicant hereby elects to file a "Statement of Water User's Claim" or an "Amended Statement of Water User's Claim" in the pending GENERAL DETERMINATION OF WATER RIGHTS; and the applicant requests that said statement be prepared by the State Engineer and submitted for execution at an early date.

Deane Zeller
APPLICANT
Deane Zeller
Salt Lake District Manager

SUBSCRIBED AND SWORN TO BEFORE ME THIS 17th DAY OF February 19 87.

[signature]
NOTARY PUBLIC

My Commission Expires June 13, 1988

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Dire
Dee C. Hansen, State Engir

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

January 29, 1985

U.S. Department of Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

RE: A-58905 (16-696)

Dear Appropriator:

Recently you received approval from the State Engineer on the above-numbered Application. Part of the filing called for the construction of a dam 5 feet high which would create a reservoir capacity of 0.1 acre-feet. The dam is to be located in Section 33, T2N, R8W, SLB&M.

Your Application will serve as notice to the State Engineer that you plan to construct a dam, thus satisfying Section 73-5-12 of the Utah Code Annotated 1953. No plans or specifications will be required, but it is requested that we be notified when the construction of the dam is complete.

Sincerely,

Robert L. Morgan

Robert L. Morgan, P.E.
Directing Dam Safety Engineer

RLM/cp

cc: Weber Area Office
Central Files

Form 33

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Engineer

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

August 3, 1984

USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT 84119

Dear Applicant:

RE: APPROVED APPLICATION
NUMBER 16-696 (A58905)

Enclosed is a copy of the above-numbered approved Application. This is your authority to proceed with actual construction work which, under Sections 73-3-10 and 73-3-12, Utah Code Annotated, 1953, as amended, must be diligently prosecuted to completion. The water must be put to beneficial use and proof of appropriation be made to the State Engineer on or before the proof due date shown below otherwise, the application will be lapsed.

*** PROOF DUE DATE: October 31, 1987 ***

Proof of Appropriation is evidence to the State Engineer that the water has been placed to its full intended beneficial use. By law, it must be prepared by a registered engineer or land surveyor, who will certify to the location and the uses for the water. Your proof of appropriation will become the basis for the extent of your water right.

Failure on your part to comply with the requirements of the statutes may result in the forfeiture of this application.

Yours truly,

Dee C. Hansen, P.E.
State Engineer

Enclosure: Copy of Approved Application

RECEIVED
JUN 02 1983
WATER RIGHTS

Form 97 2M 10-70

Application No. 58905
R-17, #38
16-696

APPLICATION TO APPROPRIATE WATER
STATE OF UTAH

NOTE:—The information given in the following blanks should be free from explanatory matter, but when necessary, a complete supplementary statement should be made on the following page under the heading "Explanatory."

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, for uses indicated by (X) in the proper box or boxes, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

1. Irrigation ☐ Domestic ☐ Stockwatering ☒ Municipal ☐ Power ☐ Mining ☐ Other Uses ☒
2. The name of the applicant is U.S. Department of Interior Bureau of Land Management
3. The Post Office address of the applicant is 2370 South 2300 West S.L.C. Utah 84119
4. The quantity of water to be appropriated ______ second-feet and/or 0.1 acre-feet
5. The water is to be used for Stockwatering (Major Purpose) from Jan (Month) 1 (Day) to Dec (Month) 31 (Day)
other use period Wildlife (Minor Purpose) from Jan 1 (Month) (Day) to Dec 31 (Month) (Day)
and stored each year (if stored) from ______ (Month) (Day) to ______ (Month) (Day)
6. The drainage area to which the direct source of supply belongs is ______ (Leave Blank)
Surface runoff collected by an
7. The direct source of supply is* Earthen impoundment (stockwatering reservoir) (Name of stream or other source) 3-23-84 by letter
which is tributary to ______, tributary to ______

*Note.—Where water is to be diverted from a well, a tunnel, or drain, the source should be designated as "Underground Water" in the first space and the remaining spaces should be left blank. If the source is a stream, a spring, a spring area, or a drain, so indicate in the first space, giving its name, if named, and in the remaining spaces, designate the stream channels to which it is tributary, even though the water may sink, evaporate, or be diverted before reaching said channels. If water from a spring flows in a natural surface channel before being diverted, the direct source should be designated as a stream and not a spring.

8. The point of diversion from the source is in Tooele County, situated at a point*
1500 feet South 1700 feet West of Northeast corner Section 33, T. 2N., R. 8W., SLB&M
(5 miles North of Delle)

*Note.—The point of diversion must be located definitely by course and distance or by giving the distances north or south, and east or west with reference to a United States land survey corner or United States mineral monument, if within a distance of six miles of either, or if at a greater distance, to some prominent and permanent natural object. No application will be received for filing in which the point of diversion is not defined definitely.

9. The diverting and carrying works will consist of an earthen impoundment by letter 3-27-84
10. If water is to be stored, give capacity of reservoir in acre-feet 0.1 height of dam 5 feet
area inundated in acres 0.1 legal subdivision of area inundated SW¼NE¼ Sec. 33

Page No. 2

EXPLANATORY

The following additional facts are set forth in order to define more clearly the full purpose of the proposed application:

Water claimed is intermittent in nature and is variable in amount based upon water run-off and/or precipitation frequency, intensity, and duration. Some of the reservoirs are lined with bentonite to reduce infiltration and provide stockwatering for animals of BLM permittees authorized to use public lands and water.

The reservoirs are located on BLM managed land and are currently in existence and functional.

FEES FOR APPLICATIONS TO APPROPRIATE WATER IN UTAH

Flow rate — c.f.s.	Cost	
0.0 to 0.1	$ 15.00	
over 0.1 to 0.5	30.00	
over 0.5 to 1.0	45.00	
over 1.0 to 15.0	45.00	plus $7.50 for each cfs above the first cubic foot per second.
over 15.0	150.00	

Storage — acre-feet		
0 to 20	22.50	
over 20 to 500	45.00	
over 500 to 7500	45.00	plus $7.50 for each 500 a.f. above the first 500 acre feet.
over 7500	150.00	

(This section is not to be filled in by applicant)

STATE ENGINEER'S ENDORSEMENTS

1. 3-22-84 Application received ~~by mail~~ over counter in State Engineer's office by JB
2. .... Priority of Application brought down to, on account of application process completed.
3. 6-2-83 Application fee, $15.00, received by A.M. Rec. No. 02788
4. 7-13-83 Application microfilmed by AA Roll No. 1007-1
5. 6-23-83 Indexed by CP Platted by ....
6. 3-23-84 Application examined by JB
7. .... Application returned, ... or corrected by office ....
8. .... Corrected Application resubmitted by mail / over counter to State Engineer's office.
9. 3-23-84 Application approved for advertisement by JB KJm
10. .... Notice to water users prepared by WW
11. .... Publication began; was completed ....

EXPLANATORY CONTINUED

FILING FOR WATER IN THE STATE OF UTAH

Rec. by ______
Fee Rec. ______
Platted ______
Microfilmed ______
Roll No. ______

APPLICATION TO APPROPRIATE WATER

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

WATER USER CLAIM NO. 16 - 696 APPLICATION NO. A58905

1. PRIORITY OF RIGHT: March 22, 1984 FILING DATE: June 2, 1983

2. OWNER INFORMATION
Name: USA Bureau of Land Management
Address: 2370 South 2300 West, Salt Lake City, UT 84119
The land is owned by the applicant(s).

3. QUANTITY OF WATER: 0.1 acre feet (Ac. Ft.)

4. SOURCE: Surface Runoff (Stkwtrg: Reservoir) DRAINAGE: Great Salt Lake Desert-South
POINT(S) OF DIVERSION: COUNTY: Tooele
(1) S. 1500 feet, W. 1700 feet, from the NE Corner of Section 33, Township 2 N, Range 8 W, SLB&M
Source: Surface Runoff
Description of Diverting Works: An earthen impoundment
COMMON DESCRIPTION: 6 Miles North of Delle

5. STORAGE
Water is to be stored in Unnamed Reservoir from January 1 to December 31.
Capacity 0.1 ac.ft. innundating 0.1 acres. Height of dam 5 feet.
The area innundated by the reservoir includes all or part of each of the following legal subdivisions.

			North East Quarter				North West Quarter				South West Quarter				South East Quarter			
TOWN	RANGE	SEC	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼
2 N	8 W	33			X													

All locations in Salt Lake Base and Meridian

6. NATURE AND PERIOD OF USE
Stockwatering: From January 1 to December 31.
Wildlife: From January 1 to December 31.

7. PURPOSE AND EXTENT OF USE
Stockwatering: 600 animal units.
Lakeside Allotment

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Engineer

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

April 12, 1984

Tooele Transcript
Transcript-Bulletin Publ. Co.
Box 390
TOOELE UT 84074

Ladies and Gentlemen:

RE: Appl. No. 15-2994 (A58936)

Enclosed is a Notice to Water Users Concerning 15-2994 (A58936) for publication on April 19, 26, & May 3, 1984.

Please send two checking proofs as soon as possible before the first publication date. Upon completion of the three issues, please send two Proofs of Publication, and your last bill in duplicate within thirty days from the date of the last publication.

Yours very truly,

Dee C. Hansen

Dee C. Hansen, P.E.
State Engineer

DCH:cw

Enclosure: Notice to Water Users

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

SALT LAKE DISTRICT OFFICE
2370 SOUTH 2300 WEST
SALT LAKE CITY, UTAH 84119

RECEI
MAR 2 .
WATE

IN REPLY
REFER TO:

7250
(U-202)

MAR 2 1 1984

Mr. John Solum
Water Rights Division
Natural Resources & Energy
1636 West Temple
Salt Lake City, Utah 84116

Dear John:

Concerning your letter of February 21, 1984, we have reviewed our copies of the unapproved applications. Item Number 7 on the application, the direct source of supply, should state that the source of supply is, "surface runoff collected by an earthen impoundment, (stock watering reservoir)." None of these applications impound live water from a stream or are on a tributary; most are located on gentle slopes of Tooele County. If you have further questions, please call Sheldon Wimmer at 524-5348.

Sincerely yours,

Sheldon Wimmer

Sheldon Wimmer
Supervisory Range Conservationist

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights

Scott M. Matheson, Governo
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Engineer

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

FEBRUARY 21, 1984

U.S. Department of the Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

Dear Sir,

We are in the process of updating our files and would like to know if you still have an interest in Unapproved Applications Nos. 15-2993, 15-2994, 15-3011, 16-678, 16-679, 16-680, 16-681, 16-682, 16-683, 16-684, 16-685, 16-686, 16-687, 16-688, 16-689, 16-690, 16-691, 16-692, 16-693, 16-694, 16-695, 16-696, 16-697, 16-698, 16-699, 16-700, 16-701, 16-702, 16-703, 16-704, 16-705, 16-706, 16-707, 16-708, 16-709, 16-710, 16-711, 16-712, 16-713, 16-714, 16-715, 16-716, 16-717, 16-718, 16-719, 16-720, 17-184, 17-185, and 17-186, all of which are incompletely filled out, and none of which have been advertised.

Please advise us of your intentions as soon as possible. If we do not hear from you by March 30, 1984, we will assume you no longer have an active interest in these applications and they will be rejected.

If you have any questions feel free to contact me at the number shown on the letterhead.

Sincerely,

John E. Solum

John E. Solum
Hydrologic Engineer

JES/1
Encls.

NOTICE TO WATER USERS

The following application(s) have been filed with the State Engineer to appropriate water in Tooele County throughout the entire year unless otherwise designated. Locations in SLB&M.

15-2994 (A58936)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stockwtrg.reservoir)
POINT(S) OF DIVERSION:
(1) S. 1200 ft, from NE Cor. Sec. 29, T9S, R3W
(6 Miles East of Lofgreen)
STORAGE: In Dry Lake Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.60 acs. in NE¼NE¼, Sec. 29, T9S, R3W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 780 head of livestock
PLACE OF USE:
E½, Sec. 29, T9S, R3W.

15-3011 (A59222)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface Runoff (stock Reservoir)
POINT(S) OF DIVERSION:
(1) S. 500 ft, E. 470 ft, from NW Cor. Sec. 10, T9S, R4W
(9 Miles SE of Vernon)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 20 ft., inundating 1.00 acs. in NW¼NW¼, Sec. 10, T9S, R4W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
S½, Sec. 3, N½, Sec. 10, T9S, R4W.

15-3046 (A59789)
APPLICANT: England Construction
Box 488
Tooele, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 100 ft. to 300 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1470 ft, E. 1620 ft, from SW Cor. Sec. 5, T4S, R4W
(1 Mile South of Tooele)
PURPOSE AND PERIOD OF USE:
Domestic: 10 persons
Other:
Used in connection with a construction shop and office

PLACE OF USE:
NE¼SW¼, Sec. 5, T4S, R4W.

15-3047 (A59790)
APPLICANT: Gary & Jodean Davis
5904 Red Zinc Dr.
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: 6 in. well 100 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1454 ft, E. 411 ft, from SW Cor. Sec. 32, T5S, R5W
(1 Mile East of Clover)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Stockwatering: 10 head of livestock
Irrigation: From Apr 1 to Oct 31, total acreage 5.00 acs.
PLACE OF USE:
NW¼SW¼, Sec. 32, T5S, R5W.

15-3048 (A59799)
APPLICANT: Steven Young
9094 N. Highway 40 #22
Lake Point, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 50 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 780 ft, E. 1820 ft, from SW Cor. Sec. 2, T2S, R4W
(In Lake Point)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Irrigation: From Apr 1 to Oct 31, total acreage 0.25 acs.
PLACE OF USE:
SE¼SW¼, Sec. 2, T2S, R4W.

16-678 (A58886)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtr. reservoir)
POINT(S) OF DIVERSION:
(1) N. 2100 ft, W. 2800 ft, from SE Cor. Sec. 17, T3N, R11W
(20 Miles NE Knolls)
STORAGE: In NW Grassy Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in SW¼NE¼, SE¼, Sec. 17, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock

PLACE OF USE:
E½, Sec. 17, T3N, R11W.

16-679 (A58887)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1900 ft, E. 300 ft, from SW Cor. Sec. 35, T1N, R8W
(4 Miles East of Delle)
STORAGE: In Greasewood Pond from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.30 acs.
in NW¼SW¼, Sec. 35, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
W½, Sec. 35, T1N, R8W.

16-680 (A58888)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: Surface Runoff (stwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) S. 650 ft, W. 3150 ft, from NE Cor. Sec. 22, T1N, R8W
(5 Miles NE of Delle)
STORAGE: In Poverty Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NE¼NW¼, Sec. 22, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1600 head of livestock
PLACE OF USE:
W½, Sec. 22, T1N, R8W.

16-681 (A58889)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stckwtering Res)
POINT(S) OF DIVERSION:
(1) N. 925 ft, W. 1175 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles NW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.50 acs.
in SE¼SE¼, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock

PLACE OF USE:
E½, Sec. 15, T3N, R11W.

16-682 (A58890)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 300 ft, W. 775 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in SE¼SE¼, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock
PLACE OF USE:
SE¼, Sec. 15, T3N, R11W.

16-683 (A58891)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 375 ft, W. 4000 ft, from SE Cor. Sec. 17, T3N, R10W
(13 Miles North of Low)
STORAGE: In Milk Case Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 5 ft., inundating 0.80 acs.
in SW¼SW¼, Sec. 17, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 900 head of livestock
PLACE OF USE:
W½, Sec. 17, T3N, R10W.

16-684 (A58892)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stckwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) N. 4700 ft, E. 1325 ft, from SW Cor. Sec. 15, T3N, R10W
(14 Miles north of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NW¼NW¼, Sec. 15, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 15, T3N, R10W.

16-685 (A58893)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2800 ft, E. 150 ft, from SW Cor. Sec. 14, T3N, R10W
(14 Miles North of Low)
STORAGE: In Gary Kidd Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in $SW\frac{1}{4}NW\frac{1}{4}$, Sec. 14, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 14, T3N, R10W.

16-686 (A58894)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stckwtering Res)
POINT(S) OF DIVERSION:
(1) N. 1500 ft, W. 200 ft, from SE Cor. Sec. 13, T3N, R10W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 9 ft., inundating 0.40 acs.
in $NE\frac{1}{4}SE\frac{1}{4}$, Sec. 13, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 13, T3N, R10W.

16-687 (A58895)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1400 ft, E. 2600 ft, from SW Cor. Sec. 24, T3N, R10W
(13 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in $NW\frac{1}{4}SE\frac{1}{4}$, Sec. 24, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
E½, Sec. 24, T3N, R10W.

16-688 (A58896)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 1150 ft, from SE Cor. Sec. 34, T3N, R10W
(11 Miles North of Low)
STORAGE: In Lee's Knoll Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NE¼SE¼, Sec. 34, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
E½, Sec. 34, T3N, R10W.

16-689 (A58897)
APPLICANT: USA Bureau of Land Managment
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1300 ft, W. 1150 ft, from SE Cor. Sec. 24, T2N, R10W
(7 Miles North of Low)
STORAGE: In Central Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SE¼SE¼, Sec. 24, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
E½, Sec. 24, T2N, R10W.

16-690 (A58898)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1100 ft, W. 550 ft, from NE Cor. Sec. 30, T3N, R9W
(14 Miles NW of Delle)
STORAGE: In Grant Rogers Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NE¼NE¼, Sec. 30, T3N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 30, T3N, R9W.

16-691 (A58900)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 150 ft, E. 2200 ft, from NW Cor. Sec. 22, T2N, R10W
(5 Miles North of Low)
STORAGE: In Badger Hole Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in $NE\frac{1}{4}NW\frac{1}{4}$, Sec. 22, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 640 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 22, T2N, R10W.

16-692 (A58901)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1450 ft, E. 2750 ft, from NW Cor. Sec. 6, T2N, R9W
(10 Miles NE of Low)
STORAGE: In Howard Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in $SW\frac{1}{4}NE\frac{1}{4}$, Sec. 6, T2N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 6, T2N, R9W.

16-693 (A58902)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtring Res)
POINT(S) OF DIVERSION:
(1) S. 2700 ft, W. 1650 ft, from NE Cor. Sec. 31, T1N, R11W
(10 Miles West of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $NW\frac{1}{4}SE\frac{1}{4}$, Sec. 31, T1N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 700 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 31, T1N, R11W.

16-694 (A58903)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2300 ft, W. 1400 ft, from NE Cor. Sec. 11, T1N, R10W
(4 Miles North of Low)
STORAGE: In Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.30 acs.
in $SW\frac{1}{4}NE\frac{1}{4}$, Sec. 11, T1N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 11, T1N, R10W.

16-695 (A58904)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1650 ft, E. 700 ft, from NW Cor. Sec. 31, T1N, R8W
(Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs.
in $SW\frac{1}{4}NW\frac{1}{4}$, Sec. 31, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 31, T1N, R8W.

16-696 (A58905)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1500 ft, W. 1700 ft, from NE Cor. Sec. 33, T2N, R8W
(6 miles N. of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 5 ft., inundating 0.10 acs.
in $SW\frac{1}{4}NE\frac{1}{4}$, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock

PLACE OF USE:
E½, Sec. 33, T2N, R8W.

16-697 (A58906)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir
POINT(S) OF DIVERSION:
(1) N. 200 ft, W. 1300 ft, from SE Cor. Sec. 33, T2N, R8W
(6 Miles North of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.15 acs.
in SE¼SE¼, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
E½, Sec. 33, T2N, R8W.

16-698 (A58907)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Resevoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, E. 600 ft, from SW Cor. Sec. 10, T1N, R8W
(5 Miles North of Delle)
STORAGE: In Dead Cow Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in NW¼NW¼, Sec. 10, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
W½, Sec. 10, T1N, R8W.

16-699 (A58909)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff
POINT(S) OF DIVERSION:
(1) N. 1920 ft, W. 3300 ft, from SE Cor. Sec. 23, T10S, R10W
(17 Miles SW of Dugway)
STORAGE: In North Table Mountain Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in NE¼SW¼, Sec. 23, T10S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 23, T10S, R10W.

16-700 (A58910)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2200 ft, E. 250 ft, from SW Cor. Sec. 28, T10S, R8W
(20 Miles South of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 28, T10S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 28, T10S, R8W.

16-701 (A58911)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 2500 ft, from SE Cor. Sec. 26, T1S, R13W
(2 Miles South of Knolls)
STORAGE: In Knolls Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 26, T1S, R13W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$S\frac{1}{2}$, Sec. 26, T1S, R13W.

16-702 (A58912)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) S. 4500 ft, E. 800 ft, from NW Cor. Sec. 10, T2S, R11W
(11 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $SW\frac{1}{4}SW\frac{1}{4}$, Sec. 10, T2S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
W½, Sec. 10, T2S, R11W.

16-703 (A58913)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 300 ft, from SE Cor. Sec. 4, T3S, R11W
(15 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼SE¼, Sec. 4, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 4, T3S, R11W.

16-704 (A58914)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 800 ft, W. 2300 ft, from SE Cor. Sec. 9, T3S, R11W
(14 Miles SE of Knolls)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.30 acs.
in SW¼SE¼, Sec. 9, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 9, T3S, R11W.

16-705 (A58915)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2630 ft, E. 2250 ft, from SW Cor. Sec. 17, T3S, R10W
(15 miles South of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in NE¼SW¼, Sec. 17, T3S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
E½, Sec. 17, T3S, R10W.

16-706 (A58916)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2000 ft, W. 1850 ft, from NE Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in SW¼NE¼, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 26, T2S, R9W.

16-707 (A58917)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1750 ft, E. 2200 ft, from SW Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in NE¼SW¼, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
W½, Sec. 26, T2S, R9W.

16-708 (A58918)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 730 ft, E. 600 ft, from NW Cor. Sec. 34, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in NW¼NW¼, Sec. 34, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 34, T2S, R9W.

16-709 (A58919)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 5100 ft, W. 1200 ft, from SE Cor. Sec. 3, T3S, R9W
(12 Miles South of Delle)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs. in $NE\frac{1}{4}NE\frac{1}{4}$, Sec. 3, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 3, T3S, R9W.

16-710 (A58920)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg.) Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1800 ft, E. 350 ft, from SW Cor. Sec. 14, T3S, R9W
(13 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.20 acs. in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 14, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 14, T3S, R9W.

16-711 (A58921)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, W. 600 ft, from SE Cor. Sec. 27, T3S, R9W
(16 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.40 acs. in $NE\frac{1}{4}NE\frac{1}{4}$, Sec. 27, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
E½, Sec. 27, T3S, R9W.

16-712 (A58922)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 950 ft, E. 4550 ft, from SW Cor. Sec. 10, T4S, R9W
(18 Miles NW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in SE¼SE¼, Sec. 10, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 10, T4S, R9W.

16-713 (A58923)
APPLICANT: U.S.A. Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4850 ft, W. 250 ft, from SE Cor. Sec. 35, T4S, R9W
(14 Miles NW of Dugway)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 35, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 4000 head of livestock
PLACE OF USE:
E½, Sec. 35, T4S, R9W.

16-714 (A58924)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 720 ft, E. 320 ft, from SW Cor. Sec. 11, T6S, R7W
(9 Miles NE of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SW¼SW¼, Sec. 11, T6S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1700 head of livestock

PLACE OF USE:
W½, Sec. 11, T6S, R7W.

16-715 (A58926)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3900 ft, E. 3500 ft, from NW Cor. Sec. 27, T5S, R19W
(25 Miles S of Wendover)
STORAGE: In Jerry B. Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in NW¼SE¼, Sec. 27, T5S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 360 head of livestock
PLACE OF USE:
E½, Sec. 27, T5S, R19W.

16-716 (A58930)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) E. 1600 ft, from NW Cor. Sec. 18, T9S, R8W
(13 Miles S of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.10 acs.
in NW¼NW¼, Sec. 18, T9S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
W½, Sec. 18, T9S, R8W.

16-717 (A58931)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3650 ft, W. 1100 ft, from NE Cor. Sec. 28, T9S, R9W
(15 Miles SW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs.
in NE¼SE¼, Sec. 28, T9S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
E½, Sec. 28, T9S, R9W.

16-718 (A58932)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1000 ft, W. 750 ft, from NE Cor. Sec. 35, T8S, R8W
(10 Miles South Dugway)
STORAGE: In Winter Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in NE¼NE¼, Sec. 35, T8S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
E½, Sec. 35, T8S, R8W.

16-719 (A58933)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1800 ft, E. 2250 ft, from NW Cor. Sec. 32, T8S, R7W
(12 Miles SE of Dugway)
STORAGE: In Burton Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in NE¼NW¼, Sec. 32, T8S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 520 head of livestock
PLACE OF USE:
W½, Sec. 32, T8S, R7W.

16-720 (A58934)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwatrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3720 ft, E. 900 ft, from NE Cor. Sec. 18, T8S, R6W
(11 miles SE of Dugway)
STORAGE: In Lookout Pass Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NW¼SW¼, Sec. 18, T8S, R6W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 18, T8S, R6W.

17-184 (A58908)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2450 ft, W. 2600 ft, from SE Cor. Sec. 27, T10S, R19W
(8 Miles South of Ibapah)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in $NW\frac{1}{4}SE\frac{1}{4}$, Sec. 27, T10S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 27, T10S, R19W.

17-185 (A58927)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 3850 ft, E. 700 ft, from SW Cor. Sec. 5, T8S, R18W
(9 Miles NE of Ibapah)
STORAGE: In Berg Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.20 acs.
in $SW\frac{1}{4}NW\frac{1}{4}$, Sec. 5, T8S, R18W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 340 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 5, T8S, R18W.

17-186 (A58929)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1150 ft, E. 1000 ft, from NW Cor. Sec. 12, T9S, R19W
(3 Miles NE of Ibapah)
STORAGE: In Secret Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 12, T9S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock

PLACE OF USE:
W½, Sec. 12, T9S, R19W.

Protests resisting the granting of these applications with reasons therefore must be filed in duplicate with the State Engineer, 1636 West North Temple, Salt Lake City, Utah 84116 on or before June 2, 1984.

Dee C. Hansen, P.E.
STATE ENGINEER

Published in Tooele Transcript
on April 19, 26, & May 3, 1984.

IN THE DISTRICT COURT OF THE THIRD JUDICIAL DISTRICT

IN AND FOR TOOELE COUNTY, STATE OF UTAH

IN THE MATTER OF THE GENERAL DETERMINATION OF RIGHTS TO THE USE OF ALL THE WATER, BOTH SURFACE AND UNDERGROUND, WITHIN ALL OF TOOELE COUNTY; ALL OF JUAB COUNTY, EXCEPT THAT PORTION DRAINING TO UTAH LAKE AND TO THE SEVIER RIVER DRAINAGE; AND ALL OF MILLARD, BEAVER, AND IRON COUNTIES EXCEPT THAT PORTION IN THE SEVIER RIVER AND THE VIRGIN RIVER DRAINAGE IN UTAH.	STATEMENT OF WATER USER'S CLAIM Water Right No. 16 - 697 Civil No. 6049 Map No. 14

RECEIVED
JUL 31 1989
WATER RIGHTS
SALT LAKE

HOW TO USE THIS FORM:

This form is important to you in asserting your water rights in the pending judicial adjudication described above. Under Utah law, unless you file this form in a timely manner, your water rights cannot be recognized and you may not assert them further. The State Engineer has made a hydrographic survey of this area, which includes your water rights and uses. Your receipt of this form constitutes notice to you that the survey has been completed and that a signed Statement of Water User's Claim is due from you within 90 days. Review the information shown on this form carefully. If you agree with the information and accept it as your Statement of Water User's Claim, sign the form and file it with the District Court in Tooele, Utah. Return two copies of the form to the Division of Water Rights in Salt Lake City, Utah. If you do not agree with the information, contact the Division of Water Rights in Salt Lake City, Utah, to resolve the problem.

1. WATER RIGHT AND OWNERSHIP INFORMATION:

A. NAME: USA Bureau of Land Management INTEREST: 100%
ADDRESS: 2370 South 2300 West, Salt Lake City, UT 84119

B. TYPE OF RIGHT: Application To Appropriate No. A58906, Water User's Claim

C. PRIORITY DATE: March 22, 1984

2. SOURCE INFORMATION:

A. QUANTITY OF WATER: 0.1 acre-feet

B. DIRECT SOURCE: Surface Runoff (Stckwtrg. Reservoir

C. POINT OF DIVERSION -- SURFACE:
(1) N 200 feet W 1300 feet from SE corner, Section 33, T 2N, R 8W, SLBM
DIVERTING WORKS: Earthen impoundment SOURCE: Surface runoff

D. DRAINAGE AREA: Great Salt Lake Desert-South COUNTY: Tooele

E. STORAGE. Water is to be diverted for storage into:

6. CERTIFICATION OF CLAIM AND WAIVER OF SUMMONS:

The undersigned hereby enters their appearance in this water adjudication proceeding and hereby waives service of summons or other process and waives service of the notice of completion as required by Sections 73-4-4 and 73-3-4 of the Utah Code Annotated, 1953 as amended.

STATE OF UTAH)
) SS
COUNTY OF Salt Lake)

The undersigned swears on oath that he makes and certifies this Water User's Claim either as the claimant himself or as the duly-authorized agent of the claimant, that he has read and knows the contents of the claim, that he signs the same, and that the information supplied therein is true to the best of his knowledge and belief.

Title: District Manager (Individual or Office) Deane H. Zeller Signature

Subscribed and sworn to before me this 26th day of July, 1989

Commission expires: Notary Public TERESA L. CATLIN 2370 South 2300 West Salt Lake City, Utah 84119 My Commission Expires February 8, 1993 State of Utah Teresa L. Catlin Notary Public

63-01 FORM 77 7/77

ELECTION RECORD SHEET

Application No. A58906 W. U. Claim No. 16-697

Name of Appropriator USDI Bureau of Land Management

Address 324 South State #301, Salt Lake City, UT 84111-2303

Date Election Submitted February 19, 1987 Proof Due Date October 31, 1987

Field Checked by BS WO Date 6/26/89

CORRECTIONS AND AMENDMENTS NEEDED FOR AN AMENDATORY CHANGE

	Name and Address	Quantity of Water	Period of Use	Point of Div.	Diversion & Carrying Works	Place of Use	Extent of Use	Suppl. Water Rights	AMENDED CHANGE Date Filed	Date Approved
Field										
Office										

REMARKS:

NA

Rough Water User's Claim Prepared

Water User's Claim Typed

Dates Water User Notified:

Water User's Claim Signed

Application No.

Water User's Claim No.

FORM 152

RECEIVED
FEB 19 1987
WATER RIGHTS

A T T E N T I O N

THIS FORM IS TO BE USED ONLY WHEN WATER HAS BEEN PLACED TO FULL BENEFICIAL USE

BEFORE THE STATE ENGINEER OF THE STATE OF UTAH

ELECTION TO FILE WATER USER'S CLAIM

APPLICATION NO. 58906 16-697

STATE OF UTAH

COUNTY OF Tooele

USDI Bureau of Land Management, being first duly sworn, says that he is the owner of the above application; that the development contemplated under this application has been completed and the water placed to beneficial use.

In lieu of submitting "Proof of Appropriation" or "Proof of Change" and receiving "Certificate of Appropriation" or "Certificate of Change", the applicant hereby elects to file a "Statement of Water User's Claim" or an "Amended Statement of Water User's Claim" in the pending GENERAL DETERMINATION OF WATER RIGHTS; and the applicant requests that said statement be prepared by the State Engineer and submitted for execution at an early date.

Deane Zeller
APPLICANT
Deane Zeller,
Salt Lake District Manager

SUBSCRIBED AND SWORN TO BEFORE ME THIS 17th DAY OF February 19 87.

[signature]
NOTARY PUBLIC

My Commission Expires June 13, 1988

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights

Scott M. Matheson, Governo
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Enginee

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

January 29, 1985

U.S. Department of Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

RE: A-58906 (16-697)

Dear Appropriator:

Recently you received approval from the State Engineer on the above-numbered Application. Part of the filing called for the construction of a dam 6 feet high which would create a reservoir capacity of 0.1 acre-feet. This dam is to be located in Section 33, T2N, R8W, SLB&M.

Your Application will serve as notice to the State Engineer that you plan to construct a dam, thus satisfying Section 73-5-12 of the Utah Code Annotated 1953. No plans or specifications will be required, but it is requested that we be notified when the construction of the dam is complete.

Sincerely,

Robert L. Morgan

Robert L. Morgan, P.E.
Directing Dam Safety Engineer

RLM/cp

cc: Weber Area Office
Central Files

Form 33

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Scott M. Matheson, Governc
Temple A. Reynolds, Executive Directc
Dee C. Hansen, State Enginee

1636 West North Temple • Salt Lake City, UT 84116 • 801-533-6071

August 3, 1984

USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT 84119

Dear Applicant:

RE: APPROVED APPLICATION
NUMBER 16-697 (A58906)

Enclosed is a copy of the above-numbered approved Application. This is your authority to proceed with actual construction work which, under Sections 73-3-10 and 73-3-12, Utah Code Annotated, 1953, as amended, must be diligently prosecuted to completion. The water must be put to beneficial use and proof of appropriation be made to the State Engineer on or before the proof due date shown below otherwise, the application will be lapsed.

*** PROOF DUE DATE: October 31, 1987 ***

Proof of Appropriation is evidence to the State Engineer that the water has been placed to its full intended beneficial use. By law, it must be prepared by a registered engineer or land surveyor, who will certify to the location and the uses for the water. Your proof of appropriation will become the basis for the extent of your water right.

Failure on your part to comply with the requirements of the statutes may result in the forfeiture of this application.

Yours truly,

Dee C. Hansen, P.E.
State Engineer

Enclosure: Copy of Approved Application

RECEIVED
Form 97 2M 10-70
JUN 0 2 1983
WATER RIGHTS

Application No. 58706
R-17, #39
16-697

APPLICATION TO APPROPRIATE WATER
STATE OF UTAH

NOTE:—The information given in the following blanks should be free from explanatory matter, but when necessary, a complete supplementary statement should be made on the following page under the heading "Explanatory."

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, for uses indicated by (X) in the proper box or boxes, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

1. Irrigation ☐ Domestic ☐ Stockwatering ☒ Municipal ☐ Power ☐ Mining ☐ Other Uses ☒
2. The name of the applicant is U.S. Department of Interior Bureau of Land Management
3. The Post Office address of the applicant is 2370 South 2300 West S.L.C. Utah 84119
4. The quantity of water to be appropriated ______ second-feet and/or 0.1 acre-feet
5. The water is to be used for Stockwatering (Major Purpose) from Jan (Month) 1 (Day) to Dec (Month) 31 (Day)
   other use period Wildlife (Minor Purpose) from Jan (Month) 1 (Day) to Dec (Month) 31 (Day)
   and stored each year (if stored) from ______ (Month) ______ (Day) to ______ (Month) ______ (Day)
6. The drainage area to which the direct source of supply belongs is ______ (Leave Blank)
7. The direct source of supply is* surface runoff collected by an Earthen impoundment (stockwatering reservoir) (Name of stream or other source) 3-23-84 by letter
   which is tributary to ______, tributary to ______

*Note.—Where water is to be diverted from a well, a tunnel, or drain, the source should be designated as "Underground Water" in the first space and the remaining spaces should be left blank. If the source is a stream, a spring, a spring area, or a drain, so indicate in the first space, giving its name, if named, and in the remaining spaces, designate the stream channels to which it is tributary, even though the water may sink, evaporate, or be diverted before reaching said channels. If water from a spring flows in a natural surface channel before being diverted, the direct source should be designated as a stream and not a spring.

8. The point of diversion from the source is in Tooele County, situated at a point*
   200 feet North 1300 feet West of Southeast corner Section 33, T. 2N., R. 8W., SLB&M
   (5 miles North of Delle)

*Note.—The point of diversion must be located definitely by course and distance or by giving the distances north or south, and east or west with reference to a United States land survey corner or United States mineral monument, if within a distance of six miles of either, or if at a greater distance, to some prominent and permanent natural object. No application will be received for filing in which the point of diversion is not defined definitely.

9. The diverting and carrying works will consist of an earthen impoundment 3-23-84 by letter
10. If water is to be stored, give capacity of reservoir in acre-feet 0.1 height of dam 6 feet
    area inundated in acres 0.15 legal subdivision of area inundated SE¼SE¼, Sec. 33

Page No. 2

EXPLANATORY

The following additional facts are set forth in order to define more clearly the full purpose of the proposed application:

Water claimed is intermittent in nature and is variable in amount based upon water run-off and/or precipitation frequency, intensity, and duration. Some of the reservoirs are lined with bentonite to reduce infiltration and provide stockwatering for animals of BLM permittees authorized to use public lands and water.

The reservoirs are located on BLM managed land and are currently in existence and functional.

FEES FOR APPLICATIONS TO APPROPRIATE WATER IN UTAH

Flow rate — c.f.s.	Cost	
0.0 to 0.1	$ 15.00	
over 0.1 to 0.5	30.00	
over 0.5 to 1.0	45.00	
over 1.0 to 15.0	45.00	plus $7.50 for each cfs above the first cubic foot per second.
over 15.0	150.00	

Storage — acre-feet		
0 to 20	22.50	
over 20 to 500	45.00	
over 500 to 7500	45.00	plus $7.50 for each 500 a.f. above the first 500 acre feet.
over 7500	150.00	

(This section is not to be filled in by applicant)

STATE ENGINEER'S ENDORSEMENTS

1. 3-22-84 Application received ~~by mail~~ over counter in State Engineer's office by [illegible] Applicant ~~process~~ completed
2. .... Priority of Application brought down to, on account of ....
3. 6-2-83 Application fee, $15.00, received by [illegible] Rec. No. 02788
4. 7-13-83 Application microfilmed by [illegible] Roll No. 1007-1
5. 6-23-83 Indexed by [illegible] Platted by ....
6. 3-23-84 Application examined by [illegible]
7. .... Application returned, ... or corrected by office ....
8. .... Corrected Application resubmitted by mail / over counter to State Engineer's office.
9. 3-23-84 Application approved for advertisement by [illegible] [illegible]
10. .... Notice to water users prepared by UW
11. .... Publication began; was completed ....

Page No. 4

EXPLANATORY CONTINUED

FILING FOR WATER IN THE STATE OF UTAH

Rec. by ____________
Fee Rec. ____________
Platted ____________
Microfilmed ____________
Roll No. ____________

APPLICATION TO APPROPRIATE WATER

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

WATER USER CLAIM NO. 16 - 697 APPLICATION NO. A58906

1. PRIORITY OF RIGHT: March 22, 1984 FILING DATE: June 2, 1983

2. OWNER INFORMATION
Name: USA Bureau of Land Management
Address: 2370 South 2300 West, Salt Lake City, UT 84119
The land is owned by the applicant(s).

3. QUANTITY OF WATER: 0.1 acre feet (Ac. Ft.)

SOURCE: Surface Runoff DRAINAGE: Great Salt Lake Desert-South
POINT(S) OF DIVERSION: COUNTY: Tooele
(1) N. 200 feet, W. 1300 feet, from the SE Corner of Section 33,
Township 2 N, Range 8 W, SLB&M
Source: Surface runoff
Description of Diverting Works: Earthen impoundment
COMMON DESCRIPTION: 6 Miles North of Delle

5. STORAGE
Water is to be stored in Unnamed Reservoir from January 1 to December 31.
Capacity 0.1 ac.ft. innundating 0.15 acres. Height of dam 6 feet.
The area innundated by the reservoir includes all or part of each of the following legal subdivisions.

			North East Quarter				North West Quarter				South West Quarter				South East Quarter			
TOWN	RANGE	SEC	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼
2 N	8 W	33																X

All locations in Salt Lake Base and Meridian

6. NATURE AND PERIOD OF USE
Stockwatering: From January 1 to December 31.
Wildlife: From January 1 to December 31.

7. PURPOSE AND EXTENT OF USE
Stockwatering: 600 animal units.
Lakeside Allotment

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights
1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

Scott M. Matheson, Gove
Temple A. Reynolds, Executive Dire
Dee C. Hansen, State Engi

FEBRUARY 21, 1984

U.S. Department of the Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

Dear Sir,

We are in the process of updating our files and would like to know if you still have an interest in Unapproved Applications Nos. 15-2993, 15-2994, 15-3011, 16-678, 16-679, 16-680, 16-681, 16-682, 16-683, 16-684, 16-685, 16-686, 16-687, 16-688, 16-689, 16-690, 16-691, 16-692, 16-693, 16-694, 16-695, 16-696, 16-697, 16-698, 16-699, 16-700, 16-701, 16-702, 16-703, 16-704, 16-705, 16-706, 16-707, 16-708, 16-709, 16-710, 16-711, 16-712, 16-713, 16-714, 16-715, 16-716, 16-717, 16-718, 16-719, 16-720, 17-184, 17-185, and 17-186, all of which are incompletely filled out, and none of which have been advertised.

Please advise us of your intentions as soon as possible. If we do not hear from you by March 30, 1984, we will assume you no longer have an active interest in these applications and they will be rejected.

If you have any questions feel free to contact me at the number shown on the letterhead.

Sincerely,

John E. Solum

John E. Solum
Hydrologic Engineer

JES/l
Encls.

NOTICE TO WATER USERS

The following application(s) have been filed with the State Engineer to appropriate water in Tooele County throughout the entire year unless otherwise designated. Locations in SLB&M.

15-2994 (A58936)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stockwtrg.reservoir)
POINT(S) OF DIVERSION:
(1) S. 1200 ft, from NE Cor. Sec. 29, T9S, R3W
(6 Miles East of Lofgreen)
STORAGE: In Dry Lake Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.60 acs. in NE¼NE¼, Sec. 29, T9S, R3W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 780 head of livestock
PLACE OF USE:
E½, Sec. 29, T9S, R3W.

15-3011 (A59222)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface Runoff (stock Reservoir)
POINT(S) OF DIVERSION:
(1) S. 500 ft, E. 470 ft, from NW Cor. Sec. 10, T9S, R4W
(9 Miles SE of Vernon)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 20 ft., inundating 1.00 acs. in NW¼NW¼, Sec. 10, T9S, R4W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
S½, Sec. 3, N½, Sec. 10, T9S, R4W.

15-3046 (A59789)
APPLICANT: England Construction
Box 488
Tooele, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 100 ft. to 300 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1470 ft, E. 1620 ft, from SW Cor. Sec. 5, T4S, R4W
(1 Mile South of Tooele)
PURPOSE AND PERIOD OF USE:
Domestic: 10 persons
Other:
Used in connection with a construction shop and office

PLACE OF USE:
NE¼SW¼, Sec. 5, T4S, R4W.

15-3047 (A59790)
APPLICANT: Gary & Jodean Davis
5904 Red Zinc Dr.
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: 6 in. well 100 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1454 ft, E. 411 ft, from SW Cor. Sec. 32, T5S, R5W
(1 Mile East of Clover)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Stockwatering: 10 head of livestock
Irrigation: From Apr 1 to Oct 31, total acreage 5.00 acs.
PLACE OF USE:
NW¼SW¼, Sec. 32, T5S, R5W.

15-3048 (A59799)
APPLICANT: Steven Young
9094 N. Highway 40 #22
Lake Point, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 50 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 780 ft, E. 1820 ft, from SW Cor. Sec. 2, T2S, R4W
(In Lake Point)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Irrigation: From Apr 1 to Oct 31, total acreage 0.25 acs.
PLACE OF USE:
SE¼SW¼, Sec. 2, T2S, R4W.

16-678 (A58886)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtr. reservoir)
POINT(S) OF DIVERSION:
(1) N. 2100 ft, W. 2800 ft, from SE Cor. Sec. 17, T3N, R11W
(20 Miles NE Knolls)
STORAGE: In NW Grassy Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in SW¼NE¼, SE¼, Sec. 17, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 17, T3N, R11W.

16-679 (A58887)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1900 ft, E. 300 ft, from SW Cor. Sec. 35, T1N, R8W
(4 Miles East of Delle)
STORAGE: In Greasewood Pond from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.30 acs.
in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 35, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 35, T1N, R8W.

16-680 (A58888)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: Surface Runoff (stwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) S. 650 ft, W. 3150 ft, from NE Cor. Sec. 22, T1N, R8W
(5 Miles NE of Delle)
STORAGE: In Poverty Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in $NE\frac{1}{4}NW\frac{1}{4}$, Sec. 22, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1600 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 22, T1N, R8W.

16-681 (A58889)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stockwtering Res)
POINT(S) OF DIVERSION:
(1) N. 925 ft, W. 1175 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles NW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.50 acs.
in $SE\frac{1}{4}SE\frac{1}{4}$, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock

PLACE OF USE:
E½, Sec. 15, T3N, R11W.

16-682 (A58890)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 300 ft, W. 775 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs. in SE¼SE¼, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock
PLACE OF USE:
SE¼, Sec. 15, T3N, R11W.

16-683 (A58891)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 375 ft, W. 4000 ft, from SE Cor. Sec. 17, T3N, R10W
(13 Miles North of Low)
STORAGE: In Milk Case Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 5 ft., inundating 0.80 acs. in SW¼SW¼, Sec. 17, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 900 head of livestock
PLACE OF USE:
W½, Sec. 17, T3N, R10W.

16-684 (A58892)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stckwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) N. 4700 ft, E. 1325 ft, from SW Cor. Sec. 15, T3N, R10W
(14 Miles north of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs. in NW¼NW¼, Sec. 15, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
W½, Sec. 15, T3N, R10W.

16-685 (A58893)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2800 ft, E. 150 ft, from SW Cor. Sec. 14, T3N, R10W
(14 Miles North of Low)
STORAGE: In Gary Kidd Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in SW¼NW¼, Sec. 14, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
W½, Sec. 14, T3N, R10W.

16-686 (A58894)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stckwtering Res)
POINT(S) OF DIVERSION:
(1) N. 1500 ft, W. 200 ft, from SE Cor. Sec. 13, T3N, R10W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 9 ft., inundating 0.40 acs.
in NE¼SE¼, Sec. 13, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
E½, Sec. 13, T3N, R10W.

16-687 (A58895)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1400 ft, E. 2600 ft, from SW Cor. Sec. 24, T3N, R10W
(13 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NW¼SE¼, Sec. 24, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
E½, Sec. 24, T3N, R10W.

16-688 (A58896)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 1150 ft, from SE Cor. Sec. 34, T3N, R10W
(11 Miles North of Low)
STORAGE: In Lee's Knoll Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NE¼SE¼, Sec. 34, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
E½, Sec. 34, T3N, R10W.

16-689 (A58897)
APPLICANT: USA Bureau of Land Managment
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1300 ft, W. 1150 ft, from SE Cor. Sec. 24, T2N, R10W
(7 Miles North of Low)
STORAGE: In Central Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SE¼SE¼, Sec. 24, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
E½, Sec. 24, T2N, R10W.

16-690 (A58898)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1100 ft, W. 550 ft, from NE Cor. Sec. 30, T3N, R9W
(14 Miles NW of Delle)
STORAGE: In Grant Rogers Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NE¼NE¼, Sec. 30, T3N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
E½, Sec. 30, T3N, R9W.

16-691 (A58900)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 150 ft, E. 2200 ft, from NW Cor. Sec. 22, T2N, R10W
(5 Miles North of Low)
STORAGE: In Badger Hole Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in NE¼NW¼, Sec. 22, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 640 head of livestock
PLACE OF USE:
E½, Sec. 22, T2N, R10W.

16-692 (A58901)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1450 ft, E. 2750 ft, from NW Cor. Sec. 6, T2N, R9W
(10 Miles NE of Low)
STORAGE: In Howard Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in SW¼NE¼, Sec. 6, T2N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
W½, Sec. 6, T2N, R9W.

16-693 (A58902)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtring Res)
POINT(S) OF DIVERSION:
(1) S. 2700 ft, W. 1650 ft, from NE Cor. Sec. 31, T1N, R11W.
(10 Miles West of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in NW¼SE¼, Sec. 31, T1N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 700 head of livestock

PLACE OF USE:
E½, Sec. 31, T1N, R11W.

16-694 (A58903)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2300 ft, W. 1400 ft, from NE Cor. Sec. 11, T1N, R10W
(4 Miles North of Low)
STORAGE: In Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.30 acs.
in SW¼NE¼, Sec. 11, T1N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
E½, Sec. 11, T1N, R10W.

16-695 (A58904)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1650 ft, E. 700 ft, from NW Cor. Sec. 31, T1N, R8W
(Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs.
in SW¼NW¼, Sec. 31, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
W½, Sec. 31, T1N, R8W.

16-696 (A58905)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1500 ft, W. 1700 ft, from NE Cor. Sec. 33, T2N, R8W
(6 miles N. of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 5 ft., inundating 0.10 acs.
in SW¼NE¼, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 33, T2N, R8W.

16-697 (A58906)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir
POINT(S) OF DIVERSION:
(1) N. 200 ft, W. 1300 ft, from SE Cor. Sec. 33, T2N, R8W
(6 Miles North of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.15 acs.
in $SE\frac{1}{4}SE\frac{1}{4}$, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 33, T2N, R8W.

16-698 (A58907)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Resevoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, E. 600 ft, from SW Cor. Sec. 10, T1N, R8W
(5 Miles North of Delle)
STORAGE: In Dead Cow Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 10, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 10, T1N, R8W.

16-699 (A58909)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff
POINT(S) OF DIVERSION:
(1) N. 1920 ft, W. 3300 ft, from SE Cor. Sec. 23, T10S, R10W
(17 Miles SW of Dugway)
STORAGE: In North Table Mountain Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 23, T10S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 23, T10S, R10W.

16-700 (A58910)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2200 ft, E. 250 ft, from SW Cor. Sec. 28, T10S, R8W
(20 Miles South of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 28, T10S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 28, T10S, R8W.

16-701 (A58911)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 2500 ft, from SE Cor. Sec. 26, T1S, R13W
(2 Miles South of Knolls)
STORAGE: In Knolls Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 26, T1S, R13W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$S\frac{1}{2}$, Sec. 26, T1S, R13W.

16-702 (A58912)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) S. 4500 ft, E. 800 ft, from NW Cor. Sec. 10, T2S, R11W
(11 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $SW\frac{1}{4}SW\frac{1}{4}$, Sec. 10, T2S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 10, T2S, R11W.

16-703 (A58913)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 300 ft, from SE Cor. Sec. 4, T3S, R11W
(15 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in $NE\frac{1}{4}SE\frac{1}{4}$, Sec. 4, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 4, T3S, R11W.

16-704 (A58914)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 800 ft, W. 2300 ft, from SE Cor. Sec. 9, T3S, R11W
(14 Miles SE of Knolls)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.30 acs.
in $SW\frac{1}{4}SE\frac{1}{4}$, Sec. 9, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 9, T3S, R11W.

16-705 (A58915)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2630 ft, E. 2250 ft, from SW Cor. Sec. 17, T3S, R10W
(15 miles South of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 17, T3S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
E½, Sec. 17, T3S, R10W.

16-706 (A58916)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2000 ft, W. 1850 ft, from NE Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in SW¼NE¼, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 26, T2S, R9W.

16-707 (A58917)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1750 ft, E. 2200 ft, from SW Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in NE¼SW¼, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
W½, Sec. 26, T2S, R9W.

16-708 (A58918)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 730 ft, E. 600 ft, from NW Cor. Sec. 34, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in NW¼NW¼, Sec. 34, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
W½, Sec. 34, T2S, R9W.

16-709 (A58919)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 5100 ft, W. 1200 ft, from SE Cor. Sec. 3, T3S, R9W
(12 Miles South of Delle)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 3, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 3, T3S, R9W.

16-710 (A58920)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg.) Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1800 ft, E. 350 ft, from SW Cor. Sec. 14, T3S, R9W
(13 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.20 acs.
in NW¼SW¼, Sec. 14, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
W½, Sec. 14, T3S, R9W.

16-711 (A58921)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, W. 600 ft, from SE Cor. Sec. 27, T3S, R9W
(16 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 27, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
E½, Sec. 27, T3S, R9W.

16-712 (A58922)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 950 ft, E. 4550 ft, from SW Cor. Sec. 10, T4S, R9W
(18 Miles NW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in SE¼SE¼, Sec. 10, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 10, T4S, R9W.

16-713 (A58923)
APPLICANT: U.S.A. Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4850 ft, W. 250 ft, from SE Cor. Sec. 35, T4S, R9W
(14 Miles NW of Dugway)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 35, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 4000 head of livestock
PLACE OF USE:
E½, Sec. 35, T4S, R9W.

16-714 (A58924)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 720 ft, E. 320 ft, from SW Cor. Sec. 11, T6S, R7W
(9 Miles NE of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SW¼SW¼, Sec. 11, T6S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1700 head of livestock

PLACE OF USE:
W½, Sec. 11, T6S, R7W.

16-715 (A58926)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3900 ft, E. 3500 ft, from NW Cor. Sec. 27, T5S, R19W
(25 Miles S of Wendover)
STORAGE: In Jerry B. Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in NW¼SE¼, Sec. 27, T5S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 360 head of livestock
PLACE OF USE:
E½, Sec. 27, T5S, R19W.

16-716 (A58930)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) E. 1600 ft, from NW Cor. Sec. 18, T9S, R8W
(13 Miles S of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.10 acs.
in NW¼NW¼, Sec. 18, T9S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
W½, Sec. 18, T9S, R8W.

16-717 (A58931)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3650 ft, W. 1100 ft, from NE Cor. Sec. 28, T9S, R9W
(15 Miles SW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs.
in NE¼SE¼, Sec. 28, T9S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
E½, Sec. 28, T9S, R9W.

16-718 (A58932)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1000 ft, W. 750 ft, from NE Cor. Sec. 35, T8S, R8W
(10 Miles South Dugway)
STORAGE: In Winter Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in NE¼NE¼, Sec. 35, T8S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
E½, Sec. 35, T8S, R8W.

16-719 (A58933)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1800 ft, E. 2250 ft, from NW Cor. Sec. 32, T8S, R7W
(12 Miles SE of Dugway)
STORAGE: In Burton Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in NE¼NW¼, Sec. 32, T8S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 520 head of livestock
PLACE OF USE:
W½, Sec. 32, T8S, R7W.

16-720 (A58934)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwatrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3720 ft, E. 900 ft, from NE Cor. Sec. 18, T8S, R6W
(11 miles SE of Dugway)
STORAGE: In Lookout Pass Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NW¼SW¼, Sec. 18, T8S, R6W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 18, T8S, R6W.

17-184 (A58908)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2450 ft, W. 2600 ft, from SE Cor. Sec. 27, T10S, R19W
(8 Miles South of Ibapah)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in $NW\frac{1}{4}SE\frac{1}{4}$, Sec. 27, T10S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 27, T10S, R19W.

17-185 (A58927)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 3850 ft, E. 700 ft, from SW Cor. Sec. 5, T8S, R18W
(9 Miles NE of Ibapah)
STORAGE: In Berg Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.20 acs.
in $SW\frac{1}{4}NW\frac{1}{4}$, Sec. 5, T8S,-R18W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 340 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 5, T8S, R18W.

17-186 (A58929)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1150 ft, E. 1000 ft, from NW Cor. Sec. 12, T9S, R19W
(3 Miles NE of Ibapah)
STORAGE: In Secret Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 12, T9S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 12, T9S, R19W.

Protests resisting the granting of these applications with reasons therefore must be filed in duplicate with the State Engineer, 1636 West North Temple, Salt Lake City, Utah 84116 on or before June 2, 1984.

Dee C. Hansen, P.E.
STATE ENGINEER

Published in Tooele Transcript on April 19, 26, & May 3, 1984.

IN THE DISTRICT COURT OF THE THIRD JUDICIAL DISTRICT

IN AND FOR TOOELE COUNTY, STATE OF UTAH

IN THE MATTER OF THE GENERAL DETERMINATION OF RIGHTS TO THE USE OF ALL THE WATER, BOTH SURFACE AND UNDERGROUND, WITHIN ALL OF TOOELE COUNTY; ALL OF JUAB COUNTY, EXCEPT THAT PORTION DRAINING TO UTAH LAKE AND TO THE SEVIER RIVER DRAINAGE; AND ALL OF MILLARD, BEAVER, AND IRON COUNTIES EXCEPT THAT PORTION IN THE SEVIER RIVER AND THE VIRGIN RIVER DRAINAGE IN UTAH.	STATEMENT OF WATER USER'S CLAIM Water Right No. 16 - 698 Civil No. 6049 Map No. 14

RECEIVED
JUL 31 1989
WATER RIGHTS
SALT LAKE

HOW TO USE THIS FORM:

This form is important to you in asserting your water rights in the pending judicial adjudication described above. Under Utah law, unless you file this form in a timely manner, your water rights cannot be recognized and you may not assert them further. The State Engineer has made a hydrographic survey of this area, which includes your water rights and uses. Your receipt of this form constitutes notice to you that the survey has been completed and that a signed Statement of Water User's Claim is due from you within 90 days. Review the information shown on this form carefully. If you agree with the information and accept it as your Statement of Water User's Claim, sign the form and file it with the District Court in Tooele, Utah. Return two copies of the form to the Division of Water Rights in Salt Lake City, Utah. If you do not agree with the information, contact the Division of Water Rights in Salt Lake City, Utah, to resolve the problem.

1. WATER RIGHT AND OWNERSHIP INFORMATION:

   A. NAME: USA Bureau of Land Management INTEREST: 100%
   ADDRESS: 2370 South 2300 West, Salt Lake City, UT 84119

   B. TYPE OF RIGHT: Application To Appropriate No. A58907, Water User's Claim

   C. PRIORITY DATE: March 22, 1984

2. SOURCE INFORMATION:

   A. QUANTITY OF WATER: 0.1 acre-feet

   B. DIRECT SOURCE: Surface Runoff (Stkwtrg. Resevoir)

   C. POINT OF DIVERSION -- SURFACE:
   (1) N 4450 feet E 600 feet from SW corner, Section 10, T 1N, R 8W, SLBM
   DIVERTING WORKS: An earthen impoundment SOURCE: Surface Runoff

   D. DRAINAGE AREA: Great Salt Lake Desert-South COUNTY: Tooele

   E. STORAGE. Water is to be diverted for storage into:

6. CERTIFICATION OF CLAIM AND WAIVER OF SUMMONS:

The undersigned hereby enters their appearance in this water adjudication proceeding and hereby waives service of summons or other process and waives service of the notice of completion as required by Sections 73-4-4 and 73-3-4 of the Utah Code Annotated, 1953 as amended.

STATE OF UTAH)
) SS
COUNTY OF Salt Lake)

The undersigned swears on oath that he makes and certifies this Water User's Claim either as the claimant himself or as the duly-authorized agent of the claimant, that he has read and knows the contents of the claim, that he signs the same, and that the information supplied therein is true to the best of his knowledge and belief.

Title: District Manager (Individual or Office) Deane H. Zeller (Signature)

Subscribed and sworn to before me this 26th day of July, 1989

Commission expires: Notary Public TERESA L CATLIN 2370 South 2300 West Salt Lake City, Utah 84119 My Commission Expires February 8, 1993 State of Utah

Teresa L Catlin
Notary Public

FORM 77-107

ELECTION RECORD SHEET

Application No. A58907 W. U. Claim No. 16-698

Name of Appropriator USDI Bureau of Land Management

Address 324 South State #301, Salt Lake City, UT 84111-2303

Date Election Submitted February 19, 1987 Proof Due Date October 31, 1987

Field Checked by BSWC Date 6/20/89

CORRECTIONS AND AMENDMENTS NEEDED FOR AN AMENDATORY CHANGE

	Name and Address	Quantity of Water	Period of Use	Point of Div.	Diversion & Carrying Works	Place of Use	Extent of Use	Suppl. Water Rights	AMENDED CHANGE Date Filed	Date Approved
Field										
Office										

REMARKS:

N/A

Rough Water User's Claim Prepared ☐

Water User's Claim Typed ☐

Dates Water User Notified:

Water User's Claim Signed ☐

Application No. ____________

FORM 152

RECEIVED
FEB 19 1987
WATER RIGHTS

A T T E N T I O N

THIS FORM IS TO BE USED ONLY WHEN WATER HAS BEEN PLACED TO FULL BENEFICIAL USE

BEFORE THE STATE ENGINEER OF THE STATE OF UTAH

ELECTION TO FILE WATER USER'S CLAIM

APPLICATION NO. 58907 16-698

STATE OF UTAH

COUNTY OF Tooele

USDI Bureau of Land Management, being first duly sworn, says that he is the owner of the above application; that the development contemplated under this application has been completed and the water placed to beneficial use.

In lieu of submitting "Proof of Appropriation" or "Proof of Change" and receiving "Certificate of Appropriation" or "Certificate of Change", the applicant hereby elects to file a "Statement of Water User's Claim" or an "Amended Statement of Water User's Claim" in the pending GENERAL DETERMINATION OF WATER RIGHTS; and the applicant requests that said statement be prepared by the State Engineer and submitted for execution at an early date.

Deane Zeller
APPLICANT
Deane Zeller,
Salt Lake District Manager

SUBSCRIBED AND SWORN TO BEFORE ME THIS 17th DAY OF February 19 87.

Teresa L Catt
NOTARY PUBLIC

My Commission Expires June 13, 1988

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights

Scott M. Matheson, Gover
Temple A. Reynolds, Executive Dir
Dee C. Hansen, State Engi

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

January 29, 1985

U.S. Department of Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

RE: A-58907 (16-698)

Dear Appropriator:

Recently you received approval from the State Engineer on the above-numbered Application. Part of the filing called for the construction of a dam 8 feet high which would create a reservoir capacity of 0.1 acre-feet. This dam is to be located in Section 10, T1N, R8W, SLB&M.

Your Application will serve as notice to the State Engineer that you plan to construct a dam, thus satisfying Section 73-5-12 of the Utah Code Annotated 1953. No plans or specifications will be required, but it is requested that we be notified when the construction of the dam is complete.

Sincerely,

Robert L. Morgan

Robert L. Morgan, P.E.
Directing Dam Safety Engineer

RLM/cp

cc: Weber Area Office
Central Files

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Form 33

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Engineer

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

August 3, 1984

USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT 84119

Dear Applicant:

RE: APPROVED APPLICATION
NUMBER 16-698 (A58907)

Enclosed is a copy of the above-numbered approved Application. This is your authority to proceed with actual construction work which, under Sections 73-3-10 and 73-3-12, Utah Code Annotated, 1953, as amended, must be diligently prosecuted to completion. The water must be put to beneficial use and proof of appropriation be made to the State Engineer on or before the proof due date shown below otherwise, the application will be lapsed.

*** PROOF DUE DATE: October 31, 1987 ***

Proof of Appropriation is evidence to the State Engineer that the water has been placed to its full intended beneficial use. By law, it must be prepared by a registered engineer or land surveyor, who will certify to the location and the uses for the water. Your proof of appropriation will become the basis for the extent of your water right.

Failure on your part to comply with the requirements of the statutes may result in the forfeiture of this application.

Yours truly,

Dee C. Hansen, P.E.
State Engineer

Enclosure: Copy of Approved Application

Form 97 2M 10-70

RECEIVED
JUN 0 2 1983
WATER RIGHTS

Application No. 58907
R-19, #40
16-698

APPLICATION TO APPROPRIATE WATER
STATE OF UTAH

NOTE:—The information given in the following blanks should be free from explanatory matter, but when necessary, a complete supplementary statement should be made on the following page under the heading "Explanatory."

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, for uses indicated by (X) in the proper box or boxes, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

1. Irrigation ☐ Domestic ☐ Stockwatering ☒ Municipal ☐ Power ☐ Mining ☐ Other Uses ☒
2. The name of the applicant is U.S. Department of Interior Bureau of Land Management
3. The Post Office address of the applicant is 2370 South 2300 West S.L.C. Utah 84119
4. The quantity of water to be appropriated ____ second-feet and/or 0.1 acre-feet
5. The water is to be used for Stockwatering (Major Purpose) from Jan (Month) 1 (Day) to Dec (Month) 31 (Day)

   other use period Wildlife (Minor Purpose) from Jan (Month) 1 (Day) to Dec (Month) 31 (Day)

   and stored each year (if stored) from ____ (Month) (Day) to ____ (Month) (Day)
6. The drainage area to which the direct source of supply belongs is ____ (Leave Blank)
7. The direct source of supply is* [surface runoff collected by an] Earthen impoundment (stockwatering reservoir) (Name of stream or other source) 3-23-84 by letter BS

   which is tributary to ____, tributary to ____

*Note.—Where water is to be diverted from a well, a tunnel, or drain, the source should be designated as "Underground Water" in the first space and the remaining spaces should be left blank. If the source is a stream, a spring, a spring area, or a drain, so indicate in the first space, giving its name, if named, and in the remaining spaces, designate the stream channels to which it is tributary, even though the water may sink, evaporate, or be diverted before reaching said channels. If water from a spring flows in a natural surface channel before being diverted, the direct source should be designated as a stream and not a spring.

8. The point of diversion from the source is in Tooele County, situated at a point*
   4400 feet North 600 feet East of Southwest Corner, Section 10, T. 1N., R. 8W., SLB&M
   (Dead Cow Point Reservoir)
   (5 miles North of Delle)

*Note.—The point of diversion must be located definitely by course and distance or by giving the distances north or south, and east or west with reference to a United States land survey corner or United States mineral monument, if within a distance of six miles of either, or if at a greater distance, to some prominent and permanent natural object. No application will be received for filing in which the point of diversion is not defined definitely.

9. The diverting and carrying works will consist of an earthen impoundment 3-23-84 by letter BS
10. If water is to be stored, give capacity of reservoir in acre-feet 0.1 height of dam 8 feet

Page No. 2

EXPLANATORY

The following additional facts are set forth in order to define more clearly the full purpose of the proposed application:

Water claimed is intermittent in nature and is variable in amount based upon water run-off and/or precipitation frequency, intensity, and duration. Some of the reservoirs are lined with bentonite to reduce infiltration and provide stockwatering for animals of BLM permittees authorized to use public lands and water.

The reservoirs are located on BLM managed land and are currently in existence and functional.

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Scott M. Matheson, Governo
Temple A. Reynolds, Executive Directo
Dee C. Hansen, State Enginee

1636 West North Temple · Salt Lake City, UT 84116 · 801-533-6071

April 12, 1984

Tooele Transcript
Transcript-Bulletin Publ. Co.
Box 390
TOOELE UT 84074

Ladies and Gentlemen:

RE: Appl. No. 15-2994 (A58936)

Enclosed is a Notice to Water Users Concerning 15-2994 (A58936) for publication on April 19, 26, & May 3, 1984.

Please send two checking proofs as soon as possible before the first publication date. Upon completion of the three issues, please send two Proofs of Publication, and your last bill in duplicate within thirty days from the date of the last publication.

Yours very truly,

Dee C. Hansen

Dee C. Hansen, P.E.
State Engineer

DCH:cw

Enclosure: Notice to Water Users

FEES FOR APPLICATIONS TO APPROPRIATE WATER IN UTAH

Flow rate — c.f.s.	Cost	
0.0 to 0.1	$ 15.00	
over 0.1 to 0.5	30.00	
over 0.5 to 1.0	45.00	
over 1.0 to 15.0	45.00	plus $7.50 for each cfs above the first cubic foot per second.
over 15.0	150.00	

Storage — acre-feet		
0 to 20	22.50	
over 20 to 500	45.00	
over 500 to 7500	45.00	plus $7.50 for each 500 a.f. above the first 500 acre feet.
over 7500	150.00	

(This section is not to be filled in by applicant)

STATE ENGINEER'S ENDORSEMENTS

1. 3-22-84 Application received ~~by mail~~ over counter in State Engineer's office by JB application form completed
2. .... Priority of Application brought down to, on account of ....
3. 6-2-83 Application fee, $15.00, received by A.M. Rec. No. 02788
4. 7-13-83 Application microfilmed by AA Roll No. 1007-1
5. 6-23-83 Indexed by CP Platted by ....
6. 3-23-84 Application examined by JB
7. .... Application returned, ... or corrected by office ....
8. .... Corrected Application resubmitted by mail / over counter to State Engineer's office.
9. 3-23-84 Application approved for advertisement by JB KJ
10. .... Notice to water users prepared by WW
11. .... Publication began; was completed ....

ENTERED - DATE 4-4-84 [illegible]
VERIFIED - DATE 7-1-[illegible] [illegible]

Page No. 4

EXPLANATORY CONTINUED

FILING FOR WATER IN THE STATE OF UTAH

Rec. by ____________
Fee Rec. ____________
Platted ____________
Microfilmed ____________
Roll No. ____________

APPLICATION TO APPROPRIATE WATER

For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of the Laws of Utah.

WATER USER CLAIM NO. 16 - 698 APPLICATION NO. A58907

1. PRIORITY OF RIGHT: March 22, 1984 FILING DATE: June 2, 1983

2. OWNER INFORMATION
Name: USA Bureau of Land Management
Address: 2370 South 2300 West, Salt Lake City, UT 84119
The land is owned by the applicant(s).

3. QUANTITY OF WATER: 0.1 acre feet (Ac. Ft.)

4. SOURCE: Surface Runoff (Stkwtrg. Resevoir) DRAINAGE: Great Salt Lake Desert-South
POINT(S) OF DIVERSION: COUNTY: Tooele
(1) N. 4400 feet, E. 600 feet, from the SW Corner of Section 10,
Township 1 N, Range 8 W, SLB&M
Source: Surface Runoff
Description of Diverting Works: An earthen impoundment
COMMON DESCRIPTION: 5 Miles North of Delle

5. STORAGE
Water is to be stored in Dead Cow Point Reservoir from January 1 to December 31.
Capacity 0.1 ac.ft. innundating 0.2 acres. Height of dam 8 feet.
The area innundated by the reservoir includes all or part of each of the following legal subdivisions.

			North East Quarter				North West Quarter				South West Quarter				South East Quarter			
TOWN	RANGE	SEC	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼
1 N	8 W	10						X										

All locations in Salt Lake Base and Meridian

6. NATURE AND PERIOD OF USE
Stockwatering: From January 1 to December 31.
Wildlife: From January 1 to December 31.

7. PURPOSE AND EXTENT OF USE
Stockwatering: 600 animal units.
Lakeside Allotment

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
SALT LAKE DISTRICT OFFICE
2370 SOUTH 2300 WEST
SALT LAKE CITY, UTAH 84119

RECE
MAR 2
WATER RI

IN REPLY REFER TO:

7250
(U-202)

MAR 2 1 1984

Mr. John Solum
Water Rights Division
Natural Resources & Energy
1636 West Temple
Salt Lake City, Utah 84116

Dear John:

Concerning your letter of February 21, 1984, we have reviewed our copies of the unapproved applications. Item Number 7 on the application, the direct source of supply, should state that the source of supply is, "surface runoff collected by an earthen impoundment, (stock watering reservoir)." None of these applications impound live water from a stream or are on a tributary; most are located on gentle slopes of Tooele County. If you have further questions, please call Sheldon Wimmer at 524-5348.

Sincerely yours,

Sheldon Wimmer

Sheldon Wimmer
Supervisory Range Conservationist

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights
1636 West North Temple • Salt Lake City, UT 84116 • 801-533-6071

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Dir
Dee C. Hansen, State Eng

FEBRUARY 21, 1984

U.S. Department of the Interior
Bureau of Land Management
2370 South 2300 West
Salt Lake City, Utah 84119

Dear Sir,

We are in the process of updating our files and would like to know if you still have an interest in Unapproved Applications Nos. 15-2993, 15-2994, 15-3011, 16-678, 16-679, 16-680, 16-681, 16-682, 16-683, 16-684, 16-685, 16-686, 16-687, 16-688, 16-689, 16-690, 16-691, 16-692, 16-693, 16-694, 16-695, 16-696, 16-697, 16-698, 16-699, 16-700, 16-701, 16-702, 16-703, 16-704, 16-705, 16-706, 16-707, 16-708, 16-709, 16-710, 16-711, 16-712, 16-713, 16-714, 16-715, 16-716, 16-717, 16-718, 16-719, 16-720, 17-184, 17-185, and 17-186, all of which are incompletely filled out, and none of which have been advertised.

Please advise us of your intentions as soon as possible. If we do not hear from you by March 30, 1984, we will assume you no longer have an active interest in these applications and they will be rejected.

If you have any questions feel free to contact me at the number shown on the letterhead.

Sincerely,

John E. Solum

John E. Solum
Hydrologic Engineer

JES/l
Encls.

NOTICE TO WATER USERS

The following application(s) have been filed with the State Engineer to appropriate water in Tooele County throughout the entire year unless otherwise designated. Locations in SLB&M.

15-2994 (A58936)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stockwtrg.reservoir)
POINT(S) OF DIVERSION:
(1) S. 1200 ft, from NE Cor. Sec. 29, T9S, R3W
(6 Miles East of Lofgreen)
STORAGE: In Dry Lake Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.60 acs.
in NE¼NE¼, Sec. 29, T9S, R3W:
PURPOSE AND PERIOD OF USE:
Stockwatering: 780 head of livestock
PLACE OF USE:
E½, Sec. 29, T9S, R3W.

15-3011 (A59222)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface Runoff (stock Reservoir)
POINT(S) OF DIVERSION:
(1) S. 500 ft, E. 470 ft, from NW Cor. Sec. 10, T9S, R4W
(9 Miles SE of Vernon)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 20 ft., inundating 1.00 acs.
in NW¼NW¼, Sec. 10, T9S, R4W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
S½, Sec. 3, N½, Sec. 10, T9S, R4W.

15-3046 (A59789)
APPLICANT: England Construction
Box 488
Tooele, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 100 ft. to 300 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1470 ft, E. 1620 ft, from SW Cor. Sec. 5, T4S, R4W
(1 Mile South of Tooele)
PURPOSE AND PERIOD OF USE:
Domestic: 10 persons
Other:
Used in connection with a construction shop and office

PLACE OF USE:
NE¼SW¼, Sec. 5, T4S, R4W.

15-3047 (A59790)
APPLICANT: Gary & Jodean Davis
5904 Red Zinc Dr.
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: 6 in. well 100 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 1454 ft, E. 411 ft, from SW Cor. Sec. 32, T5S, R5W
(1 Mile East of Clover)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Stockwatering: 10 head of livestock
Irrigation: From Apr 1 to Oct 31, total acreage 5.00 acs.
PLACE OF USE:
NW¼SW¼, Sec. 32, T5S, R5W.

15-3048 (A59799)
APPLICANT: Steven Young
9094 N. Highway 40 #22
Lake Point, UT
QUANTITY: 0.015 CFS
SOURCE: 6 in. well 50 ft. to 200 ft. deep.
POINT(S) OF DIVERSION:
(1) N. 780 ft, E. 1820 ft, from SW Cor. Sec. 2, T2S, R4W
(In Lake Point)
PURPOSE AND PERIOD OF USE:
Domestic: 1 family
Irrigation: From Apr 1 to Oct 31, total acreage 0.25 acs.
PLACE OF USE:
SE¼SW¼, Sec. 2, T2S, R4W.

16-678 (A58886)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtr. reservoir)
POINT(S) OF DIVERSION:
(1) N. 2100 ft, W. 2800 ft, from SE Cor. Sec. 17, T3N, R11W
(20 Miles NE Knolls)
STORAGE: In NW Grassy Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in SW¼NE¼, SE¼, Sec. 17, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 17, T3N, R11W.

16-679 (A58887)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1900 ft, E. 300 ft, from SW Cor. Sec. 35, T1N, R8W
(4 Miles East of Delle)
STORAGE: In Greasewood Pond from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.30 acs. in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 35, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 35, T1N, R8W.

16-680 (A58888)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 CFS
SOURCE: Surface Runoff (stwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) S. 650 ft, W. 3150 ft, from NE Cor. Sec. 22, T1N, R8W
(5 Miles NE of Delle)
STORAGE: In Poverty Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs. in $NE\frac{1}{4}NW\frac{1}{4}$, Sec. 22, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1600 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 22, T1N, R8W.

16-681 (A58889)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stckwtering Res)
POINT(S) OF DIVERSION:
(1) N. 925 ft, W. 1175 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles NW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.50 acs. in $SE\frac{1}{4}SE\frac{1}{4}$, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 15, T3N, R11W.

16-682 (A58890)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 300 ft, W. 775 ft, from SE Cor. Sec. 15, T3N, R11W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in $SE\frac{1}{4}SE\frac{1}{4}$, Sec. 15, T3N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 260 head of livestock
PLACE OF USE:
$SE\frac{1}{4}$, Sec. 15, T3N, R11W.

16-683 (A58891)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.5 Ac.Ft.
SOURCE: Surface runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 375 ft, W. 4000 ft, from SE Cor. Sec. 17, T3N, R10W
(13 Miles North of Low)
STORAGE: In Milk Case Reservoir from Jan 1 to Dec 31.
Capacity 0.5 ac.ft., height of dam 5 ft., inundating 0.80 acs.
in $SW\frac{1}{4}SW\frac{1}{4}$, Sec. 17, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 900 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 17, T3N, R10W.

16-684 (A58892)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (stckwtrg. reservoir)
POINT(S) OF DIVERSION:
(1) N. 4700 ft, E. 1325 ft, from SW Cor. Sec. 15, T3N, R10W
(14 Miles north of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 15, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
W½, Sec. 15, T3N, R10W.

16-685 (A58893)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2800 ft, E. 150 ft, from SW Cor. Sec. 14, T3N, R10W
(14 Miles North of Low)
STORAGE: In Gary Kidd Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in SW¼NW¼, Sec. 14, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
W½, Sec. 14, T3N, R10W.

16-686 (A58894)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stckwtering Res)
POINT(S) OF DIVERSION:
(1) N. 1500 ft, W. 200 ft, from SE Cor. Sec. 13, T3N, R10W
(14 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 9 ft., inundating 0.40 acs.
in NE¼SE¼, Sec. 13, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
E½, Sec. 13, T3N, R10W.

16-687 (A58895)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 1400 ft, E. 2600 ft, from SW Cor. Sec. 24, T3N, R10W
(13 Miles North of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NW¼SE¼, Sec. 24, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
E½, Sec. 24, T3N, R10W.

16-688 (A58896)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 1150 ft, from SE Cor. Sec. 34, T3N, R10W
(11 Miles North of Low)
STORAGE: In Lee's Knoll Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.30 acs.
in NE¼SE¼, Sec. 34, T3N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock
PLACE OF USE:
E½, Sec. 34, T3N, R10W.

16-689 (A58897)
APPLICANT: USA Bureau of Land Managment
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1300 ft, W. 1150 ft, from SE Cor. Sec. 24, T2N, R10W
(7 Miles North of Low)
STORAGE: In Central Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SE¼SE¼, Sec. 24, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
E½, Sec. 24, T2N, R10W.

16-690 (A58898)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1100 ft, W. 550 ft, from NE Cor. Sec. 30, T3N, R9W
(14 Miles NW of Delle)
STORAGE: In Grant Rogers Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NE¼NE¼, Sec. 30, T3N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 480 head of livestock

PLACE OF USE:
E½, Sec. 30, T3N, R9W.

16-691 (A58900)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 150 ft, E. 2200 ft, from NW Cor. Sec. 22, T2N, R10W
(5 Miles North of Low)
STORAGE: In Badger Hole Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in NE¼NW¼, Sec. 22, T2N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 640 head of livestock
PLACE OF USE:
E½, Sec. 22, T2N, R10W.

16-692 (A58901)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1450 ft, E. 2750 ft, from NW Cor. Sec. 6, T2N, R9W
(10 Miles NE of Low)
STORAGE: In Howard Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in SW¼NE¼, Sec. 6, T2N, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
W½, Sec. 6, T2N, R9W.

16-693 (A58902)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtring Res)
POINT(S) OF DIVERSION:
(1) S. 2700 ft, W. 1650 ft, from NE Cor. Sec. 31, T1N, R11W
(10 Miles West of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in NW¼SE¼, Sec. 31, T1N, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 700 head of livestock

PLACE OF USE:
E½, Sec. 31, T1N, R11W.

16-694 (A58903)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2300 ft, W. 1400 ft, from NE Cor. Sec. 11, T1N, R10W
(4 Miles North of Low)
STORAGE: In Puddle Valley Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.30 acs. in SW¼NE¼, Sec. 11, T1N, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
E½, Sec. 11, T1N, R10W.

16-695 (A58904)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1650 ft, E. 700 ft, from NW Cor. Sec. 31, T1N, R8W
(Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs. in SW¼NW¼, Sec. 31, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1000 head of livestock
PLACE OF USE:
W½, Sec. 31, T1N, R8W.

16-696 (A58905)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1500 ft, W. 1700 ft, from NE Cor. Sec. 33, T2N, R8W
(6 miles N. of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 5 ft., inundating 0.10 acs. in SW¼NE¼, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 33, T2N, R8W.

16-697 (A58906)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir
POINT(S) OF DIVERSION:
(1) N. 200 ft, W. 1300 ft, from SE Cor. Sec. 33, T2N, R8W
(6 Miles North of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.15 acs.
in $SE\frac{1}{4}SE\frac{1}{4}$, Sec. 33, T2N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 33, T2N, R8W.

16-698 (A58907)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Resevoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, E. 600 ft, from SW Cor. Sec. 10, T1N, R8W
(5 Miles North of Delle)
STORAGE: In Dead Cow Point Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 10, T1N, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 600 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 10, T1N, R8W.

16-699 (A58909)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff
POINT(S) OF DIVERSION:
(1) N. 1920 ft, W. 3300 ft, from SE Cor. Sec. 23, T10S, R10W
(17 Miles SW of Dugway)
STORAGE: In North Table Mountain Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.50 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 23, T10S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 23, T10S, R10W.

16-700 (A58910)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2200 ft, E. 250 ft, from SW Cor. Sec. 28, T10S, R8W
(20 Miles South of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $NW\frac{1}{4}SW\frac{1}{4}$, Sec. 28, T10S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 500 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 28, T10S, R8W.

16-701 (A58911)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 2500 ft, from SE Cor. Sec. 26, T1S, R13W
(2 Miles South of Knolls)
STORAGE: In Knolls Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 19 ft., inundating 0.50 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 26, T1S, R13W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$S\frac{1}{2}$, Sec. 26, T1S, R13W.

16-702 (A58912)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) S. 4500 ft, E. 800 ft, from NW Cor. Sec. 10, T2S, R11W
(11 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in $SW\frac{1}{4}SW\frac{1}{4}$, Sec. 10, T2S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 10, T2S, R11W.

16-703 (A58913)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1700 ft, W. 300 ft, from SE Cor. Sec. 4, T3S, R11W
(15 Miles SW of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in $NE\frac{1}{4}SE\frac{1}{4}$, Sec. 4, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 4, T3S, R11W.

16-704 (A58914)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 800 ft, W. 2300 ft, from SE Cor. Sec. 9, T3S, R11W
(14 Miles SE of Knolls)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.30 acs.
in $SW\frac{1}{4}SE\frac{1}{4}$, Sec. 9, T3S, R11W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 9, T3S, R11W.

16-705 (A58915)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2630 ft, E. 2250 ft, from SW Cor. Sec. 17, T3S, R10W
(15 miles South of Low)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.20 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 17, T3S, R10W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
$E\frac{1}{2}$, Sec. 17, T3S, R10W.

16-706 (A58916)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 2000 ft, W. 1850 ft, from NE Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in $SW\frac{1}{4}NE\frac{1}{4}$, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 26, T2S, R9W.

16-707 (A58917)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1750 ft, E. 2200 ft, from SW Cor. Sec. 26, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 26, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 26, T2S, R9W.

16-708 (A58918)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 730 ft, E. 600 ft, from NW Cor. Sec. 34, T2S, R9W
(11 Miles South of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.30 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 34, T2S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
W½, Sec. 34, T2S, R9W.

16-709 (A58919)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 5100 ft, W. 1200 ft, from SE Cor. Sec. 3, T3S, R9W
(12 Miles South of Delle)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 3, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 3, T3S, R9W.

16-710 (A58920)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg.) Reservoir)
POINT(S) OF DIVERSION:
(1) N. 1800 ft, E. 350 ft, from SW Cor. Sec. 14, T3S, R9W
(13 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.20 acs.
in NW¼SW¼, Sec. 14, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
W½, Sec. 14, T3S, R9W.

16-711 (A58921)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwrtg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4400 ft, W. 600 ft, from SE Cor. Sec. 27, T3S, R9W
(16 Miles SW of Delle)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 12 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 27, T3S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock

PLACE OF USE:
E½, Sec. 27, T3S, R9W.

16-712 (A58922)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 950 ft, E. 4550 ft, from SW Cor. Sec. 10, T4S, R9W
(18 Miles NW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in SE¼SE¼, Sec. 10, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 3000 head of livestock
PLACE OF USE:
E½, Sec. 10, T4S, R9W.

16-713 (A58923)
APPLICANT: U.S.A. Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 4850 ft, W. 250 ft, from SE Cor. Sec. 35, T4S, R9W
(14 Miles NW of Dugway)
STORAGE: In Earthen impoundment from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.40 acs.
in NE¼NE¼, Sec. 35, T4S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 4000 head of livestock
PLACE OF USE:
E½, Sec. 35, T4S, R9W.

16-714 (A58924)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 720 ft, E. 320 ft, from SW Cor. Sec. 11, T6S, R7W
(9 Miles NE of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in SW¼SW¼, Sec. 11, T6S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 1700 head of livestock

PLACE OF USE:
$W\frac{1}{2}$, Sec. 11, T6S, R7W.

16-715 (A58926)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3900 ft, E. 3500 ft, from NW Cor. Sec. 27, T5S, R19W
(25 Miles S of Wendover)
STORAGE: In Jerry B. Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in $NW\frac{1}{4}SE\frac{1}{4}$, Sec. 27, T5S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 360 head of livestock
PLACE OF USE:
$E\frac{1}{2}$, Sec. 27, T5S, R19W.

16-716 (A58930)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) E. 1600 ft, from NW Cor. Sec. 18, T9S, R8W
(13 Miles S of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec.31.
Capacity 0.1 ac.ft., height of dam 8 ft., inundating 0.10 acs.
in $NW\frac{1}{4}NW\frac{1}{4}$, Sec. 18, T9S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
$W\frac{1}{2}$, Sec. 18, T9S, R8W.

16-717 (A58931)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3650 ft, W. 1100 ft, from NE Cor. Sec. 28, T9S, R9W
(15 Miles SW of Dugway)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 7 ft., inundating 0.20 acs.
in $NE\frac{1}{4}SE\frac{1}{4}$, Sec. 28, T9S, R9W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
E½, Sec. 28, T9S, R9W.

16-718 (A58932)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.2 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1000 ft, W. 750 ft, from NE Cor. Sec. 35, T8S, R8W
(10 Miles South Dugway)
STORAGE: In Winter Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.2 ac.ft., height of dam 15 ft., inundating 0.50 acs.
in NE¼NE¼, Sec. 35, T8S, R8W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock
PLACE OF USE:
E½, Sec. 35, T8S, R8W.

16-719 (A58933)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1800 ft, E. 2250 ft, from NW Cor. Sec. 32, T8S, R7W
(12 Miles SE of Dugway)
STORAGE: In Burton Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.20 acs.
in NE¼NW¼, Sec. 32, T8S, R7W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 520 head of livestock
PLACE OF USE:
W½, Sec. 32, T8S, R7W.

16-720 (A58934)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwatrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 3720 ft, E. 900 ft, from NE Cor. Sec. 18, T8S, R6W
(11 miles SE of Dugway)
STORAGE: In Lookout Pass Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NW¼SW¼, Sec. 18, T8S, R6W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 6000 head of livestock

PLACE OF USE:
W½, Sec. 18, T8S, R6W.

17-184 (A58908)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (Stkwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) N. 2450 ft, W. 2600 ft, from SE Cor. Sec. 27, T10S, R19W
(8 Miles South of Ibapah)
STORAGE: In Unnamed Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 10 ft., inundating 0.40 acs.
in NW¼SE¼, Sec. 27, T10S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock
PLACE OF USE:
E½, Sec. 27, T10S, R19W.

17-185 (A58927)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface Runoff (stkwtrg reservoir)
POINT(S) OF DIVERSION:
(1) N. 3850 ft, E. 700 ft, from SW Cor. Sec. 5, T8S, R18W
(9 Miles NE of Ibapah)
STORAGE: In Berg Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 15 ft., inundating 0.20 acs.
in SW¼NW¼, Sec. 5, T8S, R18W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 340 head of livestock
PLACE OF USE:
W½, Sec. 5, T8S, R18W.

17-186 (A58929)
APPLICANT: USA Bureau of Land Management
2370 South 2300 West
Salt Lake City, UT
QUANTITY: 0.1 Ac.Ft.
SOURCE: Surface runoff (Stckwtrg. Reservoir)
POINT(S) OF DIVERSION:
(1) S. 1150 ft, E. 1000 ft, from NW Cor. Sec. 12, T9S, R19W
(3 Miles NE of Ibapah)
STORAGE: In Secret Spring Reservoir from Jan 1 to Dec 31.
Capacity 0.1 ac.ft., height of dam 6 ft., inundating 0.10 acs.
in NW¼NW¼, Sec. 12, T9S, R19W.
PURPOSE AND PERIOD OF USE:
Stockwatering: 400 head of livestock

PLACE OF USE:
W½, Sec. 12, T9S, R19W.

Protests resisting the granting of these applications with reasons therefore must be filed in duplicate with the State Engineer, 1636 West North Temple, Salt Lake City, Utah 84116 on or before June 2, 1984.

Dee C. Hansen, P.E.
STATE ENGINEER

Published in Tooele Transcript on April 19, 26, & May 3, 1984.

APPENDIX 4.5
Water Rights Data

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 16-533(A38841)

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 09/18/2003 Page 1

WRNUM: 16-533 APPLICATION/CLAIM NO.: A38841 CERT. NO.:

OWNERSHIP***

NAME: Gardner, Jack M. OWNER MISC:
ADDR: 220 Felt Bldg.
CITY: Salt Lake City STATE: UT ZIP: 84111

NAME: Stewart, Douglas D. OWNER MISC:
ADDR: 220 Felt Bldg
CITY: Salt Lake City STATE: UT ZIP: 84111

NAME: Stock, Eldon M. OWNER MISC:
ADDR: 220 Felt Bldg.
CITY: Salt Lake City STATE: UT ZIP: 84111

LAND OWNED BY APPLICANT?

DATES, ETC.***

FILING: 06/04/1968|PRIORITY: 06/04/1968|ADV BEGAN: 07/05/1968|ADV ENDED: |NEWSPAPER:
PROTST END: |PROTESTED: (Yes) |APPR/REJ: [ ]|APPR/REJ: |PROOF DUE: |EXTENSION:
ELEC/PROOF:[ ]|ELEC/PROOF: |CERT/WUC: |LAP, ETC: 06/22/1984|PROV LETR: |RENOVATE:
RECON REQ: |TYPE: [ ]

PD Book No. Map: Date Verified: 02/27/1984 Initials: WHS

Type of Right: Application to Appropriate Source of Info: Application to Appropriate Status: BAD STATUS

LOCATION OF WATER RIGHT***

FLOW: 5.0 cfs SOURCE: Underground Water Well

COUNTY: Tooele COMMON DESCRIPTION:

POINTS OF DIVERSION -- UNDERGROUND:
(1) N 1500 ft W 500 ft from SE cor, Sec 04, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(2) S 2800 ft E 1400 ft from NW cor, Sec 10, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(3) N 300 ft 0 ft from S4 cor, Sec 21, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(4) N 300 ft W 300 ft from SE cor, Sec 29, T 1N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(5) N 2640 ft W 2640 ft from SE cor, Sec 06, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(6) N 1850 ft E 1600 ft from SW cor, Sec 08, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 109 to ft. YEAR DRILLED: WELL LOG?
Comment:
(7) N 750 ft W 2000 ft from SE cor, Sec 17, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(8) S 2000 ft E 2400 ft from NW cor, Sec 17, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(9) S 1800 ft W 900 ft from NE cor, Sec 20, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(10) N 2600 ft W 2800 ft from SE cor, Sec 28, T 2N, R 8W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:
(11) S 2800 ft W 1500 ft from NE cor, Sec 33, T 2N, R 8W, SLBM DIAM: ins. DEPTH: to ft. YEAR DRILLED: WELL LOG?
Comment:
(12) N 100 ft W 20 ft from SE cor, Sec 36, T 3N, R 9W, SLBM DIAM: 12 ins. DEPTH: 100 to 500 ft. YEAR DRILLED: WELL LOG?
Comment:

PLACE OF USE OF WATER RIGHT***

NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE

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Sec 04 T  1N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 10 T  1N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *
Sec 21 T  1N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 28 T  1N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 29 T  1N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 06 T  2N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 08 T  2N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *
Sec 08 T  2N R  8W SLBM    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *    *  :  :  :  *
Sec 17 T  2N R  8W SLBM    * X: X: X: X*    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 20 T  2N R  8W SLBM    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *    *  :  :  :  *
Sec 28 T  2N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
Sec 33 T  2N R  8W SLBM    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *    * X: X: X: X*
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USES OF WATER RIGHT**

CLAIMS USED FOR PURPOSE DESCRIBED: 533

Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###DOMESTIC: 30 Persons Diversion Limit: PERIOD OF USE: 01/01 TO 12/31

###MINING: DISTRICT: Lakeside NAME: Lost Silver Lode PERIOD OF USE: 01/01 TO 12/31
ORES: Gold,Silver,Lead,Zinc

###OTHER Processing and washing gravel.

OTHER COMMENTS***

Protested by U.S. Bureau of Land Management.
Wells Nos. 1, 2, 3, and 12 will also be used for milling of ores.
This application REJECTED by Memorandum Decision dated June 22, 1984.

END OF DATA

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 16-696(A58905)

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 09/18/2003 Page 1

WRNUM: 16-696 APPLICATION/CLAIM NO.: A58905 CERT. NO.:

OWNERSHIP

NAME: USA Bureau of Land Management OWNER MISC:
ADDR: 2370 South 2300 West
CITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%

LAND OWNED BY APPLICANT? Yes

DATES, ETC.

FILING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
PROTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
ELEC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
RECON REQ: |TYPE: [ ]

PD Book No. Map: 14 Date Verified: 08/07/1989 Initials: WHS

Type of Right: Application to Appropriate Source of Info: Water User's Claim Status: WUC Signed

LOCATION OF WATER RIGHT

FLOW: 0.1 acre-feet SOURCE: Surface Runoff (Stkwtrg. Reservoir)

COUNTY: Tooele COMMON DESCRIPTION: 6 miles N. of Delle

POINT OF DIVERSION -- SURFACE:
(1) S 1500 ft W 1700 ft from NE cor, Sec 33, T 2N, R 8W, SLBM
Diverting Works: An earthen impoundment Source: Surface Runoff

PLACE OF USE OF WATER RIGHT

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 33 T 2N R 8W SLBM	* : : : *	* : : X: *	* : : : *	* : : : *

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 696
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Lakeside Allotment

###WILDLIFE Incidental wildlife purposes.

Storage from 01/01 to 12/31, inclusive, in Unnamed Reservoir with a maximum capacity of 0.100 acre-feet, located in:

		NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
Height of Dam:	5				
Area Inundated:	0.10	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 33 T 2N R 8W SLBM		* : : : *	* : : X: *	* : : : *	* : : : *

OTHER COMMENTS

The required information necessary to complete this application was not received until March 22, 1984, even though it was originally filed June 2, 1983. The priority date is thus brought down to March 22, 1984.

END OF DATA

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 16-697(A58906)

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 09/18/2003 Page 1

WRNUM: 16-697 APPLICATION/CLAIM NO.: A58906 CERT. NO.:

OWNERSHIP**

NAME: USA Bureau of Land Management OWNER MISC:
ADDR: 2370 South 2300 West
CITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%

LAND OWNED BY APPLICANT? Yes

DATES, ETC.**

FILING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
PROTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
ELEC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
RECON REQ: |TYPE: [ ]

PD Book No. Map: 14 Date Verified: 08/07/1989 Initials: WHS

Type of Right: Application to Appropriate Source of Info: Water User's Claim Status: WUC Signed

LOCATION OF WATER RIGHT**

FLOW: 0.1 acre-feet SOURCE: Surface Runoff (Stckwtrg. Reservoir

COUNTY: Tooele COMMON DESCRIPTION: 6 Miles North of Delle

POINT OF DIVERSION -- SURFACE:
(1) N 200 ft W 1300 ft from SE cor, Sec 33, T 2N, R 8W, SLBM
Diverting Works: Earthen impoundment Source: Surface runoff

PLACE OF USE OF WATER RIGHT**

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 33 T 2N R 8W SLBM	* : : : *	* : : : *	* : : : *	* : : : X*

USES OF WATER RIGHT**

CLAIMS USED FOR PURPOSE DESCRIBED: 697
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Lakeside Allotment

###WILDLIFE Incidental wildlife purposes.

Storage from 01/01 to 12/31, inclusive, in Unnamed Reservoir with a maximum capacity of 0.100 acre-feet, located in:

		NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
Height of Dam:	6				
Area Inundated:	0.15	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 33 T 2N R 8W SLBM		* : : : *	* : : : *	* : : : *	* : : : X*

OTHER COMMENTS**

The required information necessary to complete this application was not received until March 22, 1984, even though it was originally filed June 2, 1983. The priority date is thus brought down to March 22, 1984.

END OF DATA

STATE OF UTAH -- DIVISION OF WATER RIGHTS -- DATA PRINT OUT for 16-698(A58907)

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 09/18/2003 Page 1

WRNUM: 16-698 APPLICATION/CLAIM NO.: A58907 CERT. NO.:

OWNERSHIP

NAME: USA Bureau of Land Management OWNER MISC:
ADDR: 2370 South 2300 West
CITY: Salt Lake City STATE: UT ZIP: 84119 INTEREST: 100%

LAND OWNED BY APPLICANT? Yes

DATES, ETC.

FILING: 06/02/1983|PRIORITY: 03/22/1984|ADV BEGAN: 04/19/1984|ADV ENDED: |NEWSPAPER: Tooele Transcript
PROTST END:06/02/1984|PROTESTED: [No] |APPR/REJ: [Approved]|APPR/REJ: 08/03/1984|PROOF DUE: 10/31/1987|EXTENSION:
ELEC/PROOF:[Election]|ELEC/PROOF:02/19/1987|CERT/WUC: 07/31/1989|LAP, ETC: |PROV LETR: |RENOVATE:
RECON REQ: |TYPE: [ ]

PD Book No. Map: 14 Date Verified: 08/07/1989 Initials: WHS

Type of Right: Application to Appropriate Source of Info: Water User's Claim Status: WUC Signed

LOCATION OF WATER RIGHT

FLOW: 0.1 acre-feet SOURCE: Surface Runoff (Stkwtrg. Resevoir)

COUNTY: Tooele COMMON DESCRIPTION: 5 Miles North of Delle

POINT OF DIVERSION -- SURFACE:
(1) N 4450 ft E 600 ft from SW cor, Sec 10, T 1N, R 8W, SLBM
Diverting Works: An earthen impoundment Source: Surface Runoff

PLACE OF USE OF WATER RIGHT

	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 10 T 1N R 8W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 698
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 600 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Lakeside Allotment

###WILDLIFE Incidental Wildlife purposes.

Storage from 01/01 to 12/31, inclusive, in Dead Cow Point Reservoir with a maximum capacity of 0.100 acre-feet, located in:

Height of Dam: 8	NORTH-WEST¼	NORTH-EAST¼	SOUTH-WEST¼	SOUTH-EAST¼
Area Inundated: 0.20	NW NE SW SE	NW NE SW SE	NW NE SW SE	NW NE SW SE
Sec 10 T 1N R 8W SLBM	* X: : : *	* : : : *	* : : : *	* : : : *

OTHER COMMENTS

The required information necessary to complete this application was not received until March 22, 1984, even though it was originally filed June 2, 1983. The priority date is thus brought down to March 22, 1984.

END OF DATA

UTAH DIVISION OF WATER RIGHTS
WATER RIGHT POINT OF DIVERSION PLOT CREATED FRI, SEP 1
PLOT SHOWS LOCATION OF 3 POINTS OF DIV

PLOT OF ALL QUARTER(S) IN SECTION 33 TOWNSHIP 2N RAN

PLOT SCALE IS APPROXIMATELY 1 INCH = 1000 FE

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UTAH DIVISION OF WATER RIGHTS
NWPLAT POINT OF DIVERSION LOCATION PRO

MAP CHAR	WATER RIGHT	CFS	QUANTITY AND/OR	AC-FT	SOURCE DESCRIPTION or WELL INFO DIAMETER	DEPTH	YEAR LOG	POIN NORTH
0	16 696	.0000		.10	Surface Runoff (Stkwtrg. Reser			S 1500
	WATER USE(S): STOCKWATERING OTHER							
	USA Bureau of Land Management				2370 South 2300 West			
1	16 533	5.0000		.00	Underground Water Well			S 2800
	WATER USE(S): DOMESTIC MINING OTHER							
	Stock, Eldon M.				220 Felt Bldg.			
	Stewart, Douglas D.				220 Felt Bldg			
	Gardner, Jack M.				220 Felt Bldg.			
2	16 697	.0000		.10	Surface Runoff (Stckwtrg. Res			N 200
	WATER USE(S): STOCKWATERING OTHER							
	USA Bureau of Land Management				2370 South 2300 West			

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                                  UTAH DIVISION OF WATER RIGHTS
                 WATER RIGHT POINT OF DIVERSION PLOT CREATED FRI, SEP 1
                            PLOT SHOWS LOCATION OF      1 POINTS OF DIV

                PLOT OF ALL QUARTER(S) IN SECTION 4   TOWNSHIP 1N    RAN

                        PLOT SCALE IS APPROXIMATELY  1 INCH =    1000 FE

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UTAH DIVISION OF WATER RIGHTS
NWPLAT POINT OF DIVERSION LOCATION PRO

MAP CHAR	WATER RIGHT	QUANTITY CFS	AND/OR	AC-FT	SOURCE DESCRIPTION or WELL INFO DIAMETER	DEPTH	YEAR LOG	POIN NORTH
0	16 533	5.0000		.00	12	100 - 500		N 1500

WATER USE(S): DOMESTIC MINING OTHER
Stock, Eldon M. 220 Felt Bldg.
Stewart, Douglas D. 220 Felt Bldg
Gardner, Jack M. 220 Felt Bldg.

UTAH DIVISION OF WATER RIGHTS
WATER RIGHT POINT OF DIVERSION PLOT CREATED FRI, SEP 1
PLOT SHOWS LOCATION OF 2 POINTS OF DIV

PLOT OF ALL QUARTER(S) IN SECTION 10 TOWNSHIP 1N RAN

PLOT SCALE IS APPROXIMATELY 1 INCH = 1000 FE

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UTAH DIVISION OF WATER RIGHTS
NWPLAT POINT OF DIVERSION LOCATION PRO

MAP CHAR	WATER RIGHT	CFS	QUANTITY AND/OR	AC-FT	SOURCE DESCRIPTION or WELL INFO DIAMETER	DEPTH	YEAR LOG	POIN NORTH
0	16 698	.0000		.10	Surface Runoff (Stkwtrg. Resev			N 4450
	WATER USE(S): STOCKWATERING OTHER							
	USA Bureau of Land Management				2370 South 2300 West			
1	16 533	5.0000		.00	12	100 - 500		S 2800
	WATER USE(S): DOMESTIC MINING OTHER							
	Stock, Eldon M.				220 Felt Bldg.			
	Stewart, Douglas D.				220 Felt Bldg			
	Gardner, Jack M.				220 Felt Bldg.			

APPENDIX 4.6
Water Right Approval Letter

JON M. HUNTSMAN, JR.
Governor
GARY R. HERBERT
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Water Rights

MICHAEL R. STYLER
Executive Director

JERRY D. OLDS
State Engineer/Division Director

ORDER OF THE STATE ENGINEER
For Application to Appropriate Water 16-854 (A75618)

Application to Appropriate Water 16-854 (A75618) in the name of State of Utah, School & Institutional Trust Lands Administration was filed on November 19, 2004, to appropriate 100.00 acre-feet of water from point(s) located: (1) Well - North 70 feet and West 600 feet from the SE Corner of Section 4, T1N, R8W, SLB&M (8-inch well, 100-300 feet deep). The water is to be used for industrial purposes (Landfill Construction and Operation).

Notice of the application was published in the Tooele Transcript on December 16 and December 23, 2004. No protests were received.

It is the opinion of the State Engineer that there is unappropriated water that can be developed under this application. The applicant is put on notice that diligence must be shown in pursuing the development of this application by completing the proposed project.

It is, therefore, **ORDERED** and Application to Appropriate Water Number 16-854 (A75618) is hereby **APPROVED** subject to prior rights

This is your authority to develop the water under the above referenced application which under Sections 73-3-10 and 73-3-12, Utah Code Annotated, 1953, as amended, must be diligently prosecuted to completion. The water must be put to beneficial use and proof filed on or before **February 28, 2010**, or a request for extension if time must be acceptably filed; otherwise the application will be lapsed. This approval is limited to the rights to divert and beneficially use water and does not grant any rights of access to nor use of land or facilities not owned by the applicant.

As noted, this approval is granted subject to prior rights. The applicant shall be liable to mitigate or provide compensation for any impairment of or interference with prior rights as such may be stipulated among parties or decreed by a court of competent jurisdiction.

Proof of beneficial use is evidence to the State Engineer that the water has been placed to its full intended beneficial use. By law, it must be prepared by a registered engineer or land surveyor, who will certify to the location and uses of the extent of your water right.

Failure on your part to comply with the requirements of the statutes may result in forfeiture of this Application to Appropriate Water.

It is the applicant's responsibility to maintain a current address with this office and to update ownership of their water right. Please notify this office immediately of any change of address or for assistance in updating ownership.

Your contact with this office, should you need it, is with the Weber River/Western Regional Office. The telephone number is 801-538-7240.

This Order is subject to the provisions of Administrative Rule R655-6-17 of the Division of Water Rights and to Sections 63-46b-13 and 73-3-14 of the Utah Code which provide for filing either a Request for Reconsideration with the State Engineer or an appeal with the appropriate District Court. A Request for Reconsideration must be filed with the State Engineer within 20 days of the date of this Order. However, a Request for Reconsideration is not a prerequisite to filing a court appeal. A court appeal must be filed within 30 days after the date of this Order, or if a Request for Reconsideration has been filed, within 30 days after the date the Request for Reconsideration is denied. A Request for Reconsideration is considered denied when no action is taken 20 days after the Request is filed.

Dated this 2nd day of February, 2005.

Jerry D. Olds

Jerry D. Olds, P.E., State Engineer

Mailed a copy of the foregoing Order this 2nd day of February, 2005 to:

State of Utah, School & Institutional Trust Lands Administration
675 East 500 South Suite 500
Salt Lake City, UT 84102

BY: Kelly K. Horne

Kelly K. Horne, Appropriation Secretary

APPENDIX 4.7
Ground Water Sampling and Analysis Plan

GROUNDWATER SAMPLING AND ANALYSIS PLAN (GWSAP)

WASATCH REGIONAL LANDFILL
TOOELE COUNTY, UTAH

Project No: 05-04-09

Prepared for

Wasatch Regional Landfill

April 2005

Revised August 2005

Prepared by:

The Carel Corporation
136 Pecan Street
Keller, TX 76248

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1 INTRODUCTION

The following sampling and analysis plan covers the procedures for collecting representative samples from groundwater monitoring wells and the laboratory requirements for obtaining valid, defensible data. The scope is limited to sampling and analysis requirements and does not include monitor well placement, design and construction, or well development procedures.

The plan is a general requirement for groundwater monitoring sampling and analysis based primarily on the federal requirements in 40 CFR Part 258, current EPA guidance documents, and Utah Administrative Code (UAC) R315-308-2 Solid Waste Permitting and Management Rules.

2 FIELD PROCEDURES

2.1 Field Sampling Health and Safety Plan

A health and safety plan is required for all groundwater sampling events at the Wasatch Regional Landfill. Prior to monitoring well purging and sampling, the sampling contractor's Groundwater Sampling Health and Safety Plan must be in place. Designing the site Groundwater Sampling Health and Safety Plan will be the duty of the party performing the actual work.

In addition, each laboratory facility should have their own standard laboratory health and safety plan as required by current OSHA regulations.

2.2 Sample Event Preparation and QA/QC

2.2.1 General Event Preparation

The laboratory performing the groundwater analysis shall supply all necessary coolers, pre-cleaned containers, trip blanks, chemical preservatives, labels, custody seals, and chain-of-custody and shipping forms. All field data shall be entered on a Field Data Sheet (see example provided as Appendix A) or equivalent form. Adequate instructions to the laboratory must be given in advance of each monitoring event. Details concerning any changes to the monitoring plan and/or procedures need to be given to the laboratory prior to the field sampling personnel arriving on the site. A specific contact person shall be established at both the facility and contract laboratory for communication between the two (2) parties.

2.2.2 Sample Container Selection

Sample containers need to be constructed of a material compatible and non-reactive with the material it is to contain. Consult Appendix B, *Recommended Containerization and Preservation of Samples*, to determine the number, type and volume of appropriate containers. As noted in Section 2.1.1, the contract laboratory performing the analysis shall supply all the required containers. In special circumstances when the facility must obtain its own containers, these containers will be purchased from local container distributors with the exception of the septum vials and PTFE (e.g. Teflon®) lined caps required for organic analyses which are available from laboratory supply companies. Metal lids shall not be utilized for any sample containers.

2.2.3 Container Preparation

Sample containers will be purchased as a pre-cleaned product or cleaned in the laboratory in a manner consistent with EPA protocol.

2.2.4 Sample Equipment Preparation

This section outlines the equipment preparation prior to site arrival for a specific monitoring event. This equipment preparation includes minimum decontamination procedures for water level indicator(s), pH/temperature meter, specific conductivity meter, turbidity meter, and filtration device. Operation and calibration of equipment will be as per the manufacturer's instructions. All non-dedicated equipment will be thoroughly cleaned prior to arrival at the site and between sampling points as follows:

- Water Level Indicator(s) - Water level indicator(s) will be decontaminated prior to initial site arrival by hand washing the sensor probe and entire length of tape in a non-phosphate detergent followed by rinsing with organic free water. While the tape is reeled back onto the carrying spool, the tape and probe will be wiped down with a clean dry paper towel.

- Field Parameter (Temperature, pH, Specific Conductivity, Turbidity) Measuring Device(s) – Field parameter measuring device(s) will be decontaminated by hand washing the sample cells in a non-phosphate detergent followed by rinsing with deionized water. Meters will then be checked for proper calibration and operation as per the manufacturer's instructions. Any malfunctioning meters will be replaced prior to packing. Field parameter measuring device(s) will be rinsed with deionized water after each measurement.

- Sampling devices associated with groundwater sampling will be cleaned in non-phosphate detergent, followed by rinsing with deionized water.

Multiple-use equipment (e.g. water level indicators and filter chambers) must be thoroughly decontaminated and cleaned as described in this section to prevent cross contamination from prior use at other facilities. All field instruments must be properly checked and calibrated prior to arrival on-site at a sampling location.

2.2.5 Field QA/QC Samples

Field QA/QC samples consist of two (2) primary areas of quality control. The first part is the quality control of sample contamination, which may occur in the field and/or shipping procedures. This is monitored in the trip blank(s), field blank(s), and the equipment (rinsate) blank(s). A basic description of each is as follows:

- Trip Blank - These samples will be prepared in the laboratory by filling the appropriate clean sample containers with organic-free water and adding the applicable chemical preservative, if any, as indicated in Appendix B for each type of sample. These containers are to be labeled "Trip Blank", the analyses to be performed on each container indicated, and then shipped in the typical transportation cooler to the field and back to the laboratory along with the other sample set containers for a given event. This blank is tested for any contamination that may occur as a result of the containers, sample coolers, cleaning procedures, or chemical preservatives used. Trip blanks shall be taken and analyzed for each sampling event or a minimum of a one (1) in twenty (20) batch per monitoring event for volatile organic compounds (VOCs).

- Field Blank - Field blank containers will be prepared in the field at a routine sample collection point during a monitoring event by filling the appropriate sample containers from the field supply of organic free water. This field supply water shall be the same water used for cleaning and decontamination of all field purge and sample equipment. This blank is tested for any contamination that may occur as a result of site ambient air conditions and serves as an additional check for contamination in the containers, sample transport coolers, cleaning procedures, and any chemical preservatives. Field blanks shall be taken and analyzed for each sampling event or a minimum of a one (1) in twenty (20) batch per monitoring event for VOCs.

- Equipment (Rinsate) Blank - These blanks will be prepared in the field immediately following decontamination cleaning procedures on any non-dedicated equipment used for purging, sampling or sample filtration. Following decontamination, field supply organic-free water is passed through the non-dedicated equipment in the same procedure as a groundwater sample. This blank confirms proper field decontamination procedures on non-dedicated equipment utilized in the field. Equipment blanks shall be taken and analyzed for all applicable parameters anytime non-dedicated equipment is used or new equipment is being dedicated to a well at a batch minimum of one (1) in twenty (20) per monitoring event.

Other Field QA/QC Samples - A second area of standard field QA/QC samples are field duplicates.

- Field duplicates are an extra set of samples taken at a particular monitoring point and labeled "Field Duplicate". These are independent samples that are collected as close as possible to the same point in space and time. They are two (2) separate samples taken from the same source, stored in separate containers, and analyzed independently. Field duplicates are useful in documenting the precision of the sampling and analytical process. Samples shall be collected in proper alternating order for the sample point and field duplicate for each parameter (e.g. VOA - VOA, metals - metals, etc.) Field duplicates shall be taken and analyzed at a batch minimum of one (1) in twenty (20).

Appropriate field QA/QC documentation should be recorded in the field notes (e.g. locations where the field blank or duplicate were collected).

2.3 Well Purge

2.3.1 General Well Purge Information

Purging a monitoring well is just as important as the subsequent sampling of the well. Water standing in a monitor well over a certain period of time may become unrepresentative of formation water because of chemical and biochemical changes which may cause water quality alterations. Prior to monitoring well purge, inspection of the monitoring well integrity will be performed utilizing the Field Data Sheet (Appendix A) or equivalent form.

2.3.2 Water Level Measurement

Prior to any purge or sampling activity at each monitoring well, a water level measurement is required to be taken. Measurement of the static water level is important in determining the hydrogeologic characteristics of the subsurface (e.g. upgradient and downgradient). The water level indicator will be an electronic sensor device, which signals by audio or light indicator when the probe contacts the water.

Water level indicator equipment will be constructed of chemically inert materials and, during mobilization preparation and following each monitoring point, be decontaminated with a non-phosphate detergent followed with multiple deionized water rinses. Water levels will be measured with a precision of +/- 0.01 foot. Water level indicator devices will be periodically checked for proper calibration. Each monitor well shall have a reference elevation point located and properly marked at the top of the riser casing established by a licensed surveyor. This reference point elevation is measured in relation to Mean Sea Level (MSL).

Ground water elevations in wells that monitor the same waste management area must be measured within a forty-eight (48) hour period to avoid temporary variations in groundwater flow, which could preclude accurate determination of groundwater flow rate and direction.

2.3.3 Purge Equipment and Procedure

Well purging will take place from hydraulically upgradient wells to hydraulically downgradient wells. If known impacts exist, purging will take place from the least impacted well to the most impacted well. Prior to purge, the sample personnel will put on clean disposable nitrile gloves and an initial water level will be taken as described in Section 2.3.2.

Groundwater wells will be purged with dedicated bladder pumps. These pumps will remain dedicated to each respective well throughout monitoring unless replacement is necessary due to damage or wear, in which case repairs will be completed or a new pump will be dedicated. Purge procedures for dedicated equipment are described in Section 2.3.3.1. Pump intakes will be located as close as possible to the middle of the screened interval.

2.3.3.1 Dedicated Equipment

Low-flow purging will be employed using dedicated bladder pumps. Well purging will be conducted at a rate of approximately 100 milliliters per minute until a minimum of two pump and tubing volumes have been removed and stabilization of field parameters is achieved. Field parameters include temperature, specific conductivity, pH, and turbidity.

- Parameter stabilization is defined as:
  - Specific Conductivity = ± ~~10~~ 3% for three (3) consecutive measurements
  - pH = ± ~~0.2~~ 0.1 standard pH units for three (3) consecutive measurements
  - Temperature = ± 10% for three (3) consecutive measurements
  - Turbidity = ± 10% for three (3) consecutive measurements

Measurements will be recorded on the field data sheet every three to five minutes. Water level measurement will also be taken every three to five minutes and recorded on the field data sheet. An initial decrease in water level may be expected due to pump and tubing evacuation, however, no subsequent continuous drawdown is to be expected. Should a well repeatedly not meet one or more criteria, alternate criteria may be implemented with UDEQ approval.

A bladder pump will be used for both well purging and sample collection.

Equipment:

- Bladder pump
- Bladder pump controller
- Compressed air source
- New disposable gloves of appropriate material (nitrile)
- Graduated pail and/or cylinder
- Field parameter measurement device/s

Procedure:

- Appropriate disposable gloves are to be worn during installation.
- Connect the compressed air source to the pump fitting at the top of the well.
- Start the air compressor.
- Replace disposable gloves after handling the compressor.
- Turn on the pump controller and adjust the discharge and refill cycles to the appropriate settings.
- Press the start button on the controller, which begins the pumping action.
- Adjust the controller to the desired flow rate (approximately 100 milliliters per minute).

Continue pumping until the necessary volume of water (two pump and tubing volumes minimum) has been purged from the well and field parameters have stabilized.

2.3.3.2 Non-Dedicated Equipment

In the event of a non-operative dedicated pump, the pump and tubing apparatus will be removed for repairs or replacement and the well will be purged by means of either a disposable bailer or a portable pump until such time the bladder pump is repaired/replaced and rededicated to the well. Purging will be performed by removing three well-casing volumes of water from the well or until stabilization of field parameters (as defined in Section 2.3.3.1) occurs. Purging will be deemed complete if the well goes dry before three well-casing volumes of water have been removed. Field parameters will be measured after each well-casing volume of water removed.

Equipment:

- Non-dedicated pump/bailer
- Pump controller (if required)

- Generator or other power source/driving mechanism for pumps / appropriate disposable string or rope for bailer, downrigger (optional)
- New disposable tubing
- New disposable gloves of appropriate material (nitrile).
- Graduated pail or other appropriate container.
- Field parameter measurement device(s)
- Container for laboratory grade, nonphosphate soap/reagent-grade deionized water solution
- Container for reagent-grade deionized water rinse

Procedure (Specific operating instructions vary depending on the type of portable pump used. The steps listed below are generalized procedures)

- Don a new pair of gloves.
- Cleanse portable pump/bailer with a non-phosphate, laboratory grade detergent solution followed by an reagent-grade deionized water rinse. Sufficient water should be passed through a non-dedicated pump to ensure proper cleansing.
- Remove gloves worn during cleaning and don a new pair of gloves
- Attach new disposable tubing to pump or new disposable string to bailer.
- Insert pump and tubing/bailer into well.
- Start the portable pump by the appropriate method and adjust flow to desired rate / initiate removal of water from well with bailer. Ensure bailer and string do not touch ground during purging.

When purging with a bailer, introduce bailer into water column slowly (i.e. do not "drop" into water column) to avoid agitation of water in the well and immediate formation area.

Non-dedicated equipment will be constructed of chemically inert materials and will be decontaminated at each well with a non-phosphate detergent followed with a reagent-grade deionized water rinse. Additional cleaning procedures will be performed as deemed necessary.

Rate of discharge and volume purged will be checked periodically with a graduated bucket and/or timer. Field parameter (temperature, pH, specific conductivity, and turbidity) measurements will be recorded after each well volume of water removed during purging.

2.3.4 Purge Water Management

If purge water is known to be historically contaminated or suspect due to prior analytical data, the water shall be stored in appropriate containers until analytical results are available. After review of these analyses, proper arrangements for disposal or treatment of the water shall be made. Otherwise, purge water will be discarded on the ground away from the monitor well area.

2.4 Monitoring Well Sample Collection

2.4.1 General Sample Collection Information

Sampling should take place as soon as purging is complete if the well has sufficient recharge. If the well was purged dry or significant drawdown of the water level exists immediately after purge, the monitor well should be sampled as soon as sufficient water is present for all analytes to be collected. The time interval between the completion of well purge and sample collection normally should not exceed forty-eight hours.

2.4.2 Sample Collection Order

Monitor well sampling at each event shall proceed from the point with the highest water level elevation to those with successively lower elevations unless contamination is known to be present. If contamination is known to be present, samples will be collected from the least to most contaminated wells, to minimize the potential for any cross-contamination. Samples will be collected and containerized according of the volatility of the requested analyses. A specific collection order is as follows:

- Field Parameters (Temperature, pH, Specific Conductivity, Turbidity)
- Volatile Organics
- Metals
- Inorganics

2.4.3 Sampling Equipment/Procedures

Groundwater wells will be sampled using dedicated bladder pumps. These are the same pumps used for well purging.

2.4.4 VOC Sample Collection

Filling VOC sample containers involves extra care. The water should be gently added to each vial until a positive meniscus is formed over the top of the container. This insures no headspace is present in the sample vial upon replacing the cap. After the cap has been placed on the vial and tightened, the vial should be checked for air bubbles by turning upside down and tapping with finger. If a bubble is seen rising to the top of the inverted vial, the process outlined above should be repeated. If no air bubbles are seen in each vial, the process is complete.

2.4.5 Sample Filtration

All efforts must be made to delete or minimize controllable factors to allow the collection of as representative and turbid-free sample as possible. Utah DEQ, UAC, Solid Waste Permitting and Management Rules does not currently allow for field sample filtration of constituents listed in R315-308-4 prior to laboratory analysis (R315-308-2 (4)(d)). The facility may collect samples for laboratory filtration and analysis of dissolved metals when deemed necessary. Otherwise, metal and inorganic indicator analyses will be for total concentrations.

2.4.6 Sample Preservation

All samples will be containerized and preserved according to Appendix B, *Sample Containerization and Preservation*. In the goal to obtain the most representative sample possible, preserving the sample for transportation and storage to the laboratory is also important.

Methods of preservation are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Samples requiring refrigeration to four degrees Centigrade will be accomplished by placing the sample containers immediately into coolers containing wet ice or the equivalent and delivering to the analytical laboratory as soon as possible.

2.4.7 Field Measurements

Required field measurements include water levels, temperature, pH, specific conductivity, and turbidity. Each of these measurements is important in the documentation of properly collected groundwater samples.

All instruments shall be properly calibrated and checked with standards according to the manufacturer's instructions and/or the field crew's standard operating procedures. Any improper operating instruments must be replaced prior to continuing sample collection operations.

2.5 Record Keeping

2.5.1 Field Logs

All field notes must be completely and accurately documented to become part of the final report for a monitoring event. All field information will be entered on a Field Data Sheet (see Appendix A) or equivalent form.

All entries should be legible and made in indelible ink. Entry errors will be crossed out with a single line, dated, and initialed by the person making the corrections.

2.5.2 Chain-of-Custody

Proper chain of custody records are required to insure the integrity of the samples and the conditions of the samples upon receipt at the laboratory, including the temperature of the samples at the time of log in. The sample collector shall fill in all applicable sections and forward the original, with the respective sample(s), to the laboratory performing the analysis. Upon receipt of the samples at the laboratory, the sample coordinator is to complete the chain of custody, make a copy for his/her files, and make the original documents part of the final analytical report (see example provided as Appendix C). All sample containers will be labeled to prevent misidentification. The following will be indicated on an adhesive label with a waterproof pen:

- Collector's name, date and time of sampling.
- Sample source.
- Sample Identification number.
- Sample preservatives.
- Test(s) to be performed on the sample.

Sample shuttle kits (coolers) will employ a tamper proof seal.

2.6 Sample Transport

Samples shall be shipped from the field back to the analytical laboratory either by hand delivery or utilizing an overnight courier service. Samples are to be shipped in sealed insulated shipping containers. Standard shipping containers must be a sturdy waterproof design (ice chests are commonly used) equipped with bottle dividers and cushion material to prevent breakage during shipment. Since wet ice is the most common means by which to refrigerate the samples, appropriate measures need to be taken to fully waterproof the contents from leakage. The field crew shall contact the laboratory each time samples are sent to identify the samples being sent and the transportation carrier along with the shipping identification number.

3 LABORATORY PROCEDURES/ PERFORMANCE STANDARDS

3.1 Analytical Methods

Chemical analyses will be performed by a laboratory that is certified by the State of Utah to analyze each Table 1 constituent. Methods and reporting limits will conform to Table 1 and will be performed in accordance with test procedures presented in USEPA *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, September 1986 and any subsequent revisions or additions.

Alternative methods that provide equivalent or better performance than those listed in EPA publication SW-846 and analytical methods for constituents not listed in EPA publication SW-846 may be implemented.

3.2 Deliverables (General and Supplemental QA/QC)

3.2.1 General Requirements

For general reporting of quantitative results for Subtitle D groundwater monitoring projects, the following reporting requirements apply:

- Methodology Summary - reporting of all the analytical test methods used in the analyses of the samples with a reference made for each to the method manual and the test method number to confirm compliance with Table 1.
- Summary of the analytical results, indicating appropriate unit, and reporting RL: and supervisor approval – concentration units must be consistently applied throughout report. Data cannot be method blank corrected. It must be appropriately flagged.
- Chain-of-Custody Form – As per Section 2.4.2.
- Field Data Sheets (see Appendix A) or equivalent form.

3.2.2 Supplemental QA/QC Reporting Requirements

- Laboratory Chronicles – must include date of sampling, sample receipt, preservation, preparation, analysis, and supervisor approval signature.

- Non-Conformance Summary for GC/MS Data Reports – must state if the following do not meet QA/QC requirements:

  GC/MS Tune Specifications
  GC/MS Tune Frequency
  Calibration Frequency
  Calibration Requirements – System Performance Check
  Compounds, Calibration Check Compounds
  Blank Contamination
  Surrogate Recoveries
  Sample Holding Times
  Minimum Detection Limits

3.2.3 Requirements for Organics: Volatiles

1. Quality Assurance (QA) Data Form – must include minimum detection limits, method blanks, field/trip blanks if specified in Sampling Plan, lab replicate. Quality Control (QC) samples may be other than project samples, but must be of same batch and similar matrix. A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form.

2. Surrogate Compound Recovery Summary – for samples and blanks – as per most recent version of applicable SW-846 method 8260.

3. Other requirements per Laboratory Quality Assurance Plan and regulatory requirements,

3.2.4 Laboratory Requirements for Metals

At a minimum, analytical results, method detection limits must be established and method blank results are mandatory.

3.2.5 Requirements for Inorganic - General Chemistry

Quality Assurance (QA) Data Form - must include minimum detection limits, method blanks, field/trip blanks as specified in Sampling Plan, lab replicate. Quality Control

(QC) samples may be other than project samples, but must be of same batch and similar matrix.

A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form. In addition, spiked sample results must be included.

3.3 Data Quality Objectives

3.3.1 Required Reporting Limits

Data reported must be such that the method used shall achieve the nominal reporting limits (RLs) listed in Table 1 - Background/Detection Monitoring Parameters

3.3.2 Precision

Precision refers to the reproducibility of method results when a second aliquot of the same sample undergoes duplicate analysis. The degree of agreement is expressed is the Relative Percent Difference (RPD). Precision requirements shall be as per applicable method and laboratory standards.

3.3.3 Accuracy

Accuracy refers to the agreement between the amount of a constituent measured by a test method and the amount actually known to be present. Accuracy is usually expressed as a percent Recovery (R). Accuracy shall be as per applicable method and laboratory standards.

4 SAMPLING FREQUENCY AND REPORTING REQUIREMENTS

4.1 Background

As per UAC R315-308-2 (4)(a), a minimum of eight (8) independent samples will be collected and analyzed to establish background for the constituents listed in Table 1 to establish background concentrations. Each monitor well in the site groundwater monitoring program will be defined as background or detection.

4.2 Detection Monitoring Events

After establishment of background values, sampling and analysis for both upgradient and downgradient detection monitoring wells will be conducted on a semi-annual basis (every six (6) months) for constituents listed in Table 1.

4.3 Groundwater Analysis Result Submittals

Two (2) bound copies of a report of all groundwater sampling and analysis results will be submitted to the Executive Secretary. The report will be submitted in standard laboratory format and on any applicable state agency reporting forms. Within a reasonable period of time after completing sampling, the owner/operator must determine whether there has been a statistically significant increase (SSI) over background at each monitoring well as per UAC R315-308-2 (4) (f) (v).

If there has been a statistically significant increase over background of any tested constituent at any monitoring well, a notice in writing to the UDEQ will be submitted within fourteen (14) days after the finding.

5 STATISTICAL METHODOLOGY - GROUND WATER DATA ANALYSIS

Statistical comparisons will be performed using Sanitas™, a commercial software program developed by Intelligent Decision Technologies, Inc. or another comparable computer program. Statistical analyses of groundwater data will be performed in accordance with UAC R315-308-2 (7). A statistical analysis plan has been prepared and included as Appendix D. Appendix D Statistical Analysis Plan has been prepared using generally accepted statistical analysis principals and practices (IDT, 2002). However, it is not possible to predict all of the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated.

5.1 Statistically Significant Constituents and Verification Resampling

Statistical analysis of constituents in Table 1 will commence within six (6) months after completion of eight (8) quarterly background events for a particular well. An initial Statistically Significant Increase (SSI) will be based on any compound detected in any downgradient monitor well at a concentration above the specific constituent's statistical limit. If an initial SSI of any constituent is indicated at any downgradient monitoring well, a notice will be made to the Department in the form of a statistical analysis report as referenced in Section 4.3 of this plan.

Verification resampling is an integral part of the presented statistical methodology. In the event of an initial SSI, verification resampling may be conducted and the results provided to the Executive Secretary in accordance with UAC R315-308-2 (10) (b).

As per UAC R315-308-2 (10) (c), the owner/operator may demonstrate within 90 days of the finding that the SSI is the result of a source other than the Municipal Solid Waste Landfill (MSWLF), such as error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Otherwise, the owner/operator must initiate an assessment monitoring program under UAC R315-308-2 (11).

6 REFERENCES

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Martin, W.F., Lippitt, J.M., and Protherd, T.G. 1987. *Hazardous Waste Handbook For Health and Safety,* Butterworth Publishers, Stoneham, Massachusetts, pp. 28 - 30.

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U.S. Environmental Protection Agency, 1992. *RCRA Groundwater Monitoring: Draft Technical Guidance.* EPA/530-R-93-001, NTIC # PB93-139-350, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, 1991b. *Handbook - Groundwater, Volume II: Methodology.* EPA/625/6-90/0166.

U.S. Environmental Protection Agency, November 1986. *Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, Third Edition (Revised),* SW-846. Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, November 1993. *Solid Waste Disposal Facility Criteria Technical Manual.* EPA/530-R-93-017, NTIC #PB94-100-450, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, Federal Register, 40 CFR 258, October 9, 1991.

Table 1
List of Analytical Parameters
Wasatch Regional Landfill

Inorganic Constituents	CAS	Method[1]	RL[2] (mg/L)
Ammonia as Nitrogen	7664-41-7	350.1	1
Carbonate/Bicarbonate		310.1	10
Calcium		6010 or 6020	0.6
Chemical Oxygen Demand (COD)		410.2	10
Chloride		300.0	10
Iron	7439-89-6	6010 or 6020	0.1
Magnesium		6010 or 6020	0.2
Manganese	7439-96-5	6010 or 6020	0.015
Nitrate as Nitrogen		300.0 or 353.2	5
pH		150.1	N/A
Potassium		6010 or 6020	5
Sodium		6010 or 6020	5
Sulfate		300.0 or 375.4	10
Total Dissolved Solids (TDS)		160.1	10
Total Organic Carbon (TOC)		415.1	2
Heavy Metals	**CAS**	**Method[1]**	**RL[2] (mg/L)**
Antimony	7440-36-0	6010 or 6020 or 200.8	0.005
Arsenic	7440-38-2	7041 or 6020	~~0.05~~ 0.04
Barium	7440-39-3	6010 or 6020	0.02
Beryllium	7440-41-7	7091 or 6020	0.002
Cadmium	7440-43-9	6010 or 6020	0.001
Chromium		6010 or 6020	0.05
Cobalt	7440-48-4	6010 or 6020	0.07
Copper	7440-50-8	6010 or 6020	0.05
Lead		7421 or 6020 or 200.8	~~0.015~~ 0.01
Mercury	7439-97-6	6020 or 7470	~~0.002~~ 0.001
Nickel	7440-02-0	6010 or 6020	0.01
Selenium	7782-49-2	7740 or 6010 or 6020	0.02
Silver	7440-22-4	6010 or 6020	0.07
Thallium		7841 or 6020 or 200.8	~~0.4~~ 0.002

Table 1 (Continued)

Heavy Metals	CAS	Method[1]	RL[2] (mg/L)
Vanadium	7440-62-2	6010 or 7911	0.02
Zinc	7440-66-6	6010 or 6020	0.01

Volatile Organic Compounds	CAS	Method[1]	RL[2] (μg/L)
Acetone	67-64-1	8260B	10
Acrylonitrile	107-13-1	8260B	50
Benzene	71-43-2	8260B	4
Bromochloromethane	74-97-5	8260B	4
Bromodichloromethane	75-27-4	8260B	4
Bromoform (tribromomethane)	75-25-2	8260B	4
Carbon disulfide	75-15-0	8260B	4
Carbon tetrachloride	56-23-5	8260B	4
Chlorobenzene	108-90-7	8260B	4
Chloroethane (ethyl chloride)	75-00-3	8260B	8
Chloroform (trichloromethane)	67-66-3	8260B	4
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8260B	4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260B	0.2
1,2-Dibromoethane (ethylene dibromide, EDB)	106-93-4	8260B	0.05
o-Dichlorobenzene (1,2-dichlorobenzene)	95-50-1	8260B	4
p-Dichlorobenzene (1,4 dichlorobenzene)	106-46-7	8260B	4
trans-1,4-Dichloro-2-butene	110-57-6	8260B	4
1,1-Dichloroethane (ethylidene chloride)	75-34-3	8260B	4
1,2-Dichloroethane (ethylene dichloride)	107-06-2	8260B	4
1,1-Dichloroethylene (1,1-dichloroethene)	75-35-4	8260B	4
cis-1,2-Dichloroethylene (1,1-dichloroethene)	156-59-2	8260B	4
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	156-60-5	8260B	4
1,2-Dichloropropane (propylene dichloride)	78-87-5	8260B	4
cis-1,3-dichloropropene	10061-01-5	8260B	2
trans-1,3-dichloropropene	10061-02-6	8260B	2

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Table 1` (Continued)

Volatile Organic Compounds	CAS	Method[1]	RL[2](µg/L)
Ethylbenzene	100-41-4	8260B	~~5~~ 4
2-Hexanone (methyl butyl ketone)	591-78-6	8260B	~~10~~ 5
Methyl bromide (bromomethane)	74-83-9	8260B	~~10~~ 5
Methyl chloride (chloromethane)	74-87-3	8260B	2
Methylene bromide (dibromomethane)	74-95-3	8260B	~~5~~ 4
Methylene chloride (dichloromethane)	75-09-2	8260B	~~5~~ 4
Methyl ethyl ketone (MEK, 2-butanone)	78-93-3	8260B	~~10~~ 5
Methyl iodide (iodomethane)	74-88-4	8260B	~~5~~ 4
4-Methyl-2-pentanone (methyl isobutyl ketone)	108-10-1	8260B	~~10~~ 5
Styrene	100-42-5	8260B	~~5~~ 4
1,1,1,2-Tetrachloroethane	630-20-6	8260B	~~5~~ 4
1,1,2,2-Tetrachloroethane	79-34-5	8260B	~~5~~ 4
Tetrachloroethylene (tetrachloroethene)	127-18-4	8260B	~~5~~ 4
Toluene	108-88-3	8260B	~~5~~ 4
1,1,1-Trichloroethane (methylchloroform)	71-55-6	8260B	~~5~~ 4
1,1,2-Trichloroethane	79-00-5	8260B	~~5~~ 4
Trichloroethylene (trichloroethene)	79-01-6	8260B	~~5~~ 4
Trichlorofluoromethane (CFC-11)	75-69-4	8260B	~~5~~ 4
1,2,3-Trichloropropane	96-18-4	8260B	~~5~~ 4
Vinyl acetate	108-05-4	8260B	~~10~~ 5
Vinyl chloride	75-01-4	8260B	2
Xylenes (total)	1330-20-7	8260B	~~5~~ 4

1. Equivalent or better methods may be submitted as appropriate
2. Reporting Limits

For the compounds DBCP and EDB, any detectable amount between the RL and MCL will be estimated and flagged with an appropriate symbol.

APPENDIX A

FIELD DATA SHEET

Wasatch Regional Landfill

GROUNDWATER SAMPLING
FIELD DATA SHEET

Well Number: ____________________
Sample I.D.: ______________ (if different from well no.)

Project: __________________________
Personnel: ________________________

Date: ______________
Weather: _________________ Air Temp: _____

WELL DATA:

Casing Diameter: _____ (in) ☐ PVC ☐ Other:

DEPTH TO: Static Water Level (WL): _______ (ft) Total Depth (TD): ______ (ft)

DATUM: ☐ Top of Well Casing ☐ Top of Protective Casing

CONDITION: Is well clearly labeled? ☐ Yes ☐ No

Is prot. casing in good cond.? (not bent or corroded) ☐ Yes ☐ No

Is concrete pad intact? (not cracked or frost heaved) ☐ Yes ☐ No

Is padlock functional? ☐ Yes ☐No Is inner casing intact? ☐ Yes ☐ No

Is inner casing properly capped and vented? ☐ Yes ☐ No

Comments: ____

PURGE DATA: One Casing Volume = (d/24)2 (23.5)(TD-WL)

METHOD: ☐ Bladder Pump ☐ Bailer ☐ Other: __________ Low-Flow Purging Used? ☐Yes ☐ No

MATERIALS: Type of Pump: _

Tubing: ☐Teflon® ☐ Polyethylene ☐ Polypropylene ☐ Other: __________

PURGING EQUIPMENT: ☐ Dedicated ☐ Prepared Off-Site ☐ Field-Cleaned

PROCEDURES: Pump & Tubing Vol.: ________(ml) Pumping Rate: ______ (ml/min)

CALIBRATION: pH Meter Model: ____________ Meter S/N: ____________ Time: ______

Cond. Meter Model: ____________ Meter S/N: ____________ Time: ______

Disposition of Purge Water: ____________________________________

TIME SERIES DATA:

Time:							
Cum. Volume(ml)							
Temperature (°C)							
pH (s.u.):							
Spec. Cond. (µmhos/cm):							
Turbidity (NTU):							
Other							

SAMPLING DATA:

Sample Collection Time: ______________

Water Level at Time of Sample: ______________

METHOD: ☐ Bladder Pump ☐ Bailer ☐ Other: __________

SAMPLING EQUIPMENT: ☐ Dedicated ☐ Prepared Off-Site ☐Field-Cleaned

APPEARANCE: ☐ Clear Turbid (NTU): __________Color: __________ ☐ Contains Immiscible Liquid

FIELD DETERMINATIONS: Temp. (°C):________pH (s.u.):__________Spec. Cond. (µmhos/cm): ________

General Remarks: ____

I certify that this sample was collected and handled in accordance with applicable regulatory and project protocols.

Signature:______________________________ Date:____________________

RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	Container, a	Preservative	Holding Times	Reference
Physical Properties					
Specific Cond. (Field)	100	P,G	None	Det. on Site	1
Specific Cond. (Lab)	100	P,G	Cool, 4 °C	28 Days	1
pH (Field)	50	P,G	None	Det. on Site	1,2
pH (Lab)	50	P,G	None	24 Hrs	1,2
Temperature	1000	P,G	None	Det. On Site	1
Turbidity	100	P,G	None	Det. On Site	1

Measurement	Volume (mL)	Container, a	Preservative	Holding Times	Reference
Inorganics, Non-Metallics					
Carbonate/Bicarbonate	200	P,G	Cool, 4 °C	14 days	1
Chloride	200	P,G	None	28 Days	1,2
Nitrate plus Nitrite	200	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	1,2
COD	50	P,G	H_2SO_4 to pH <2	28 days	1
Sulfate	100	P,G	Cool, 4 °C	28 days	1,2
Ammonia as Nitrogen	1000	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	2,3
Total Dissolved Solids (TDS)	500	P,G	Cool, 4 °C	7 days	2,3
Total Organic Carbon (TOC)	250	P,G	Cool, 4 °C HCL or H_2SO_4 to pH <2	28 days	2,3

Appendix B
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RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	Container[a]	Preservative	Holding Times	Reference
Metals (except mercury)					
Total	500	P,G	HNO_3 to pH <2	6 Mos	1,2
Dissolved	500	P,G	Filt. + HNO_3 to pH <2	6 Mos	1,2
Mercury – Total	500	P,G	HNO_3 to pH <2	28 days	1,2
Mercury – Dissolved	300	P,G	Filt. + HNO_3 to pH <2	28 days	1,2

Measurement	Volume (mL)	Container[a]	Preservative	Holding Times	Reference
Organics					
Volatile Organics by GC/MS	100 (2 vials @ 40ml)	G, Teflon septum cap	Cool, 4 °C HCL to pH <2	14 days	2,3
Herbicides	1000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3
Pesticides and PCB's	1000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3
Semi-Volatiles Acid and Base/Neutral Compounds	2000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3

<u>NOTES:</u>

a Plastic (P) or Glass (G). For metals, polyethylene with an all polypropylene cap is preferred.

b Maximum holding time from sampling to extraction.

c Maximum holding time from extraction to analysis.

<u>REFERENCES:</u>

1 <u>Methods for Chemical Analysis of Water and Wastes</u>, March, 1983, USEPA, 600/4-79-020 and additions thereto.

2 <u>Test Methods for Evaluating Solid Waste, Physical/Chemical Method</u>, November, 1986, Third Edition, USEPA, SW-846 and additions thereto.

3 "Guidelines Establishing Test Procedures for the Analysis of Pollutant Under the Clean Water Act", Environmental Protection Agency, <u>Code of Federal Regulations</u> (CFR), Title 40, Part 136.

APPENDIX ~~D~~ C

SAMPLE CHAIN-OF-CUSTODY

[redacted]

Chain of Custody Record

STL-4124 (0901)

SEVERN TRENT **STL**

Severn Trent Laboratories, Inc.

Client	Project Manager	Date	Chain of Custody Number 168232
Address	Telephone Number (Area Code)/Fax Number	Lab Number	Page ______ of ______
City / State / Zip Code	Site Contact / Lab Contact		
Project Name and Location (State)	Carrier/Waybill Number		
Contract/Purchase Order/Quote No.			

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H_2SO_4	HNO_3	HCl	NaOH	ZnAc/NaOH		Analysis (Attach list if more space is needed)												Special Instructions/ Conditions of Receipt

SAMPLE

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required
☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other ______

QC Requirements (Specify)

1. Relinquished By	Date	Time	1. Received By	Date	Time
2. Relinquished By	Date	Time	2. Received By	Date	Time
3. Relinquished By	Date	Time	3. Received By	Date	Time

Comments

DISTRIBUTION: WHITE - Returned to Client with Report; CANARY - Stays with the Sample; PINK - Field Copy

APPENDIX D

STATISTICAL ANALYSIS PLAN

CONTENTS

1 INTRODUCTION

This document provides a statistical methodology for groundwater monitoring at the City of Wasatch Regional Landfill. A tiered evaluation approach has been developed for detection monitoring wells. Intrawell comparisons of metals and inorganic indicator parameters will be conducted using Shewhart-CUSUM control charts. Non-parametric prediction limits combined with Sen's Slope/MannKendall trend analysis will be applied to those parameters with greater than 50 percent non-detections (25 percent under ASTM standards) in the background data set. Statistical limits for volatile organic compounds in detection monitoring wells will be based on reporting limits (RLs). Assessment monitoring constituents will be statistically evaluated using detection monitoring statisticis and 95 percent confidence interval analysis. Details of each method are provided in the following sections. Statistical comparisons will be performed using Sanitas™, a commercial software program developed by Intelligent Decision Technologies, Inc. or another comparable computer program.

This document has been prepared using generally accepted statistical analysis principals and practices. However, it is not possible to predict all of the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated.

2 DETECTION MONITORING STATISTICAL ANALYSES

2.1 Metals and Inorganic Indicator Constituents

2.1.1 Shewhart-CUSUM Control Charts

Metals and inorganic indicator constituents will be statistically evaluated using combined Shewhart-CUSUM Control Charts. This procedure assumes that the data are independent and normally distributed with a fixed mean and constant variance. The most important assumption is independence, therefore wells should be sampled no more frequently than quarterly (Gibbons, 1994). The assumption of normality is less of a concern and natural log or ladder of powers transformations are adequate for most applications. The analysis is only applied to constituents that have greater than 50 percent detections (25 percent under ASTM standards) in the background data. For those metals and inorganic indicator constituents with fewer than 50 percent detections in the background data set, a non-parametric prediction limit/Sen's Slope/Mann Kendall trend analysis will be used.

Shewhart-CUSUM control charts allow detection of both major and gradual releases from the facility independent of spatial variation. This procedure is specifically recommended in the USEPA document *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (April 1989).

2.1.2 Procedure

Control charts are a form of time-series graph, on which a parametric statistical representation of concentrations of a given constituent are plotted at intervals over time. The statistics are computed and plotted together with an upper and/or lower control limit on a chart where the x-axis represents time.

The Procedure for conducting the intrawell analysis using combined Shewhart-CUSUM Control Charts is provided below and a flow chart illustrating the decision making process is provided as Figure D-1:

Three parameters are selected prior to plotting:

h - The control limit to which the cumulative sum (CUSUM) values are compared. The EPA recommended value for **h** is 5 units of standard deviation.

k - A reference value that establishes the upper limit for the acceptable displacement of the standardized mean. The EPA recommended value for k is 1.

SCL - The upper Shewhart control limit to which the standardized mean will be compared. The EPA recommended value for **SCL** is 4.5.

For each time period, T_i, take n_i independent samples (n_i may be one), and calculate the mean, $\bar{x}_i$. Compute the standardized mean Z_i of the measured concentrations where only a single new measurement is obtained for each constituent at each event as :

$$Z_i = \left(X_i - \overline{X}\right)\sqrt{n_i} / S$$

Where:

x_i = value obtained for a constituent during monitoring event i.

s = The standard deviation obtained from prior monitoring data from the same well.

When applicable, for each time period, T_i, compute the cumulative sum, S_i, as:

$$S_i = \max\{0, (Z_i - k) + S_{i-1}\}$$

Where max {A,B} is the maximum of A and B, and $S_o = 0$.

Plot Z_i and S_i against Ti on the control chart. The results may be plotted in standardized units or converted to the concentration units of the constituents being evaluated. An "out-of-control" situation (potential contamination) occurs whenever $Z_i \geq$ SCL or $S_i \geq$ h. Two different types of situation are controlled by the limits. Too large a standardized mean will occur if there is a rapid increase in concentration in the well. Too large a cumulative sum may also occur for a more gradual trend. A verified statistically significant change (SSC) will occur if both the initial result *and* a verification sample result consecutively exceed one of the above mentioned statistical limits. Upgradient wells will be monitored for informational purposes only and will not be part of the verification resampling program.

2.1.2.1 Verification Resamples

The Shewhart and CUSUM portions of the control chart are affected differently by initial statistically significant changes from background (SSCs). The Shewhart portion of the control chart compares each individual new measurement to the control limit, therefore the next monitoring event constitutes an independent verification of the original result. However, the CUSUM procedure incorporates all historical values in the computation, therefore, the effect of the apparent SSC will be present in both the initial and verification sample. Hence, the statistical test will be invalid unless the verification sample value replaces the initial SSC value. Therefore, initial SSC values will be replaced by verification resample results in order to confirm a SSC (Gibbons, 1994).

2.1.2.2 Updating Control Charts

As monitoring continues, the background mean and variance will be updated periodically to incorporate new data. At a minimum of every two years all new data that are in control will be pooled with the initial eight background samples and the mean and variance will be recomputed and used in constructing future control charts. ~~TCEQ~~ UDEQ (Utah Department of Environmental Quality) approval will be obtained prior to updating the background data pool.

2.1.2.3 Censored Data

If less than 15 percent of the background observations are nondetects, these will be replaced with one half of the laboratory reporting limit prior to running the analysis (U.S. EPA, April 1989).

If more than 15 percent but less than 50 percent of the background data are less than the detection limit, the data's sample mean and sample standard deviation are adjusted according to the method of Cohen or Aitchison.

If more than 50 percent of the background data are less than the detection limit, a nonparametric prediction limit will be computed.

2.1.3 Non-Parametric Prediction Limits and Sen's Slope/Mann Kendall Trend Analysis

For those metals and inorganic indicator constituents with fewer than 50-percent detections within the background pool, a combined non-parametric upper prediction limit/Sen's Slope/MannKendall trend ananlysis will be applied. Parameters will be initially tested using the non-parametric prediction limit analysis. Constituents exceeding the non-parametric prediction limit will then be tested using the Sen's Slope/Mann Kendall trend analysis. An initial statistical exceedence will be indicated if the measured concentration exceeds both the non-parametric prediction limit and exhibitis a significant upward trend. The combined methods provide a non-parametric control chart equivalent to allow detection of both major and gradual releases from the facility independent of spatial variation.

2.1.3.1 Non-Parametric Prediction Limit Analysis

An upper prediction limit is a statistical limit calculated to include one or more observations from the same population with a specified confidence. In groundwater monitoring, an upper prediction limit approach may be used to make comparisons between background and compliance well data. The limit is constructed to contain all **k** observations with stated confidence. Any observation exceeding the upper prediction limit provides statistically significant evidence that the observation is not representative of the background group. The number of observations, **k**, to be compared to the limit must be specified in advance. A flow chart illustrating the decision making process during the analysis is provided as Figure D-2.

The highest value from the background data is used to set the upper prediction limit. In the case of a two-tailed test, the lowest value from the background data is used to set the lower prediction limit. Under EPA Standards, the false positive rate is based upon the formula:

$$\mathbf{1-(n/(n+k))}$$

Where:

n = The background sample size, and

k = The number of future values being compared to the limit.

2.1.3.2 Sen's Slope/Mann Kendall Trend Analysis

The Sen's Slope/Mann Kendall trend analysis procedure determines the significance of an apparent trend and evaluates the magnitude (slope) of that trend (IDT, 2002). The Mann Kendall test for temporal trend is a non-parametric procedure designed to test the null hypothesis, H_0:

H_0: No significant trend of a constituent exists over time.

And the alternative hypothesis, H_A:

H_A: A significant upward trend of a constituent concentration exists over time.

Wells for which less than 41 data points are available, the exact test is applied. For 41 or more data points, the Normal Approximation test is used.

The Sen's Slope estimator portion of the combined method provides an estimate of the true slope. The method is a non-parametric procedure not greatly affected by gross data errors or outliers, and can be computed when data are missing.

2.2 Statistical Evaluation of Volatile Organic Compounds

Volatile organic compounds (VOCs) will be routinely monitored during the detection monitoring program. The statistical limit for VOCs detected in wells under detection monitoring will be set equal to the laboratory reporting limit (RL). RLs are provided in Table 1 of the facility's Groundwater Sampling and Analysis Plan (GWSAP). As with the prediction limit statistical method, VOC detections will not be considered statistically significant unless confirmed by verification resampling. Verification resampling procedures are provided in Section 2.3 and in the GWSAP.

2.3 Verification Resampling

Results for constituents that exceed statistical limits will not be considered statistically significant unless they are confirmed through verification resampling.

If a statistically significant change (SSC) from background of any tested constituent at any monitor well has occurred (i.e. is confirmed) and there is reasonable cause that a source other than the landfill exists, then a report will be submitted documenting the source as per Section 5.1 of the GWSAP and UAC R315-308-2 (10)(c). Otherwise, assessment monitoring will be implemented in accordance with Section 5.1 of the GWSAP and UDEQ regulations.

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3 ASSESSMENT MONITORING STATISTICAL ANALYSIS

For assessment wells, constituents exceeding detection monitoring statistical limits and that have a groundwater protection standard (GWPS) established by the USEPA or the UDEQ, and/or any VOC detections will be statistically compared to GWPS using one-sided 95-percent lower confidence limits (LCL). Evaluations are conducted per Gibbons and Coleman (2001). The method constructs a normal confidence interval on the mean concentration of a constituent incorporating, at a minimum, the four most recent semi-annual measurements. A separate interval is constructed for each constituent of interest in each well of interest. A confidence interval is generally used when downgradient samples are being compared to a Groundwater Protection Standard (GWPS). A flow chart depicting the decision making process during the analysis is provided as Figure E-3.

The lower 95-percent confidence limit on the mean will be compared to a GWPS to decide initially whether the mean concentration of a constituent of interest has exceeded a GWPS. If the lower 95-percent confidence limit on the mean exceeds the GWPS then there is statistically significant evidence that the mean concentration of that constituent exceeds the GWPS. Upper 95-percent confidence limit analyses may be applied to constituents in which it's 95 percent LCL has exceeded a GWPS. If the upper 95-percent confidence limit on the mean occurs lower that the GWPS then there is statistically significant evidence that the mean concentration of that constituent has returned to less than the GWPS.

3.1 Assumptions

The sample data used to construct the limits must be normally or transformed-normally distributed. In the case of a transformed-normal distribution, the confidence limit must be constructed on the transformed sample concentration values. In addition to the limit construction, the comparison must be made to the transformed GWPS value. When none of the transformed models can be justified, a nonparametric version of each limit may be utilized.

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3.2 Distribution

The distribution of the data is evaluated by applying the Shapiro-Wilk or Shapiro-Francia test for normality to the raw data or, when applicable, to the Ladder of Powers (Helsel & Hirsch, 1992) transformed data. The null hypothesis, $\mathbf{H_O}$, to be tested is:

> $\mathbf{H_O}$: The population has a normal (or transformed-normal) distribution.

The alternative hypothesis, $\mathbf{H_A}$, is:

> $\mathbf{H_A}$: The population does not have a normal (or transformed-normal) distribution.

3.3 Censored Data

If less than 15 percent of the observations are non-dectects, these will be replaced with one half the method detection limit prior to running the normality test and constructing the confidence limit.

If more than 15 percent, but less than 50 percent, of the data are less than the detection limit, the data's sample mean and standard deviation are adjusted according to the method of Cohen or Aitchison (U.S. EPA, April 1989). This adjustment is made prior to construction of the confidence limit.

If more than 50 percent of the data are less than the detection limit, these values are replaced with one half the method detection limit and a nonparametric confidence limit is constructed.

3.4 Parametric Confidence Limit Procedures

A minimum of four sample values is required for the construction of the parametric confidence limit. The mean, **X**, and standard deviation, **S**, of the sample concentration values are calculated separately for each compliance well. For each well, the confidence limit is calculated as:

$$\overline{X} \pm t_{(1-\alpha,\, n-1)} \frac{S}{\sqrt{n}}$$

Where:

S = The compliance point's standard deviation;

n = The number of observations for the compliance point; and

$t_{(1-\alpha,,n-1)}$ is obtained from the Student's t-Distribution (appendix B; U.S. EPA, April 1989) with (n-1) degrees of freedom.

The use of the 95[th] percentile of the t-Distribution is consistent with the 5 percent α - level of individual well comparisons. If the lower limit is above the compliance limit, there is statistically significant evidence that the constituent exceeds a GWPS.

3.5 Nonparametric Confidence Limit Procedure

The nonparametric confidence limit procedure requires at least seven observations in order to obtain a one-sided significance level of 1 percent. The observations are ordered from smallest to largest and ranks are assigned separately within each well. Average ranks are assigned to tied values. The critical values of the order statistics are determined as follows.

If the minimum seven observations are used, the critical values are the first and seventh values. Otherwise, the smallest integer, **M**, is found such that the cumulative binomial distribution with parameters **n** (sample size) and probability of success, p=0.5, is at least 0.99.

The exact confidence coefficient for sample sizes from 4 to 11 are given by the EPA (Table 6-3; U.S. EPA, April 1989). For larger samples, take as an approximation the nearest integer value to:

$$\mathbf{M} = \frac{n}{2} + \mathbf{1} + \mathbf{Z}_{(1-\alpha)} \sqrt{\frac{n}{4}}$$

Where:

$\mathbf{Z}_{(1-\alpha)}$ = The 1-α percentile from the normal distribution found in Table 4 (appendix B; U.S. EPA, April 1989); and

n = The number of observations in the sample.

Once **M** has been determined, **(n+1-M)** is computed and the confidence limits are taken as the order statistics, **X(M)** and **X(n+1-M)**. These confidence limits are compared to the GWPS as discussed in Section 3.

4 REFERENCES

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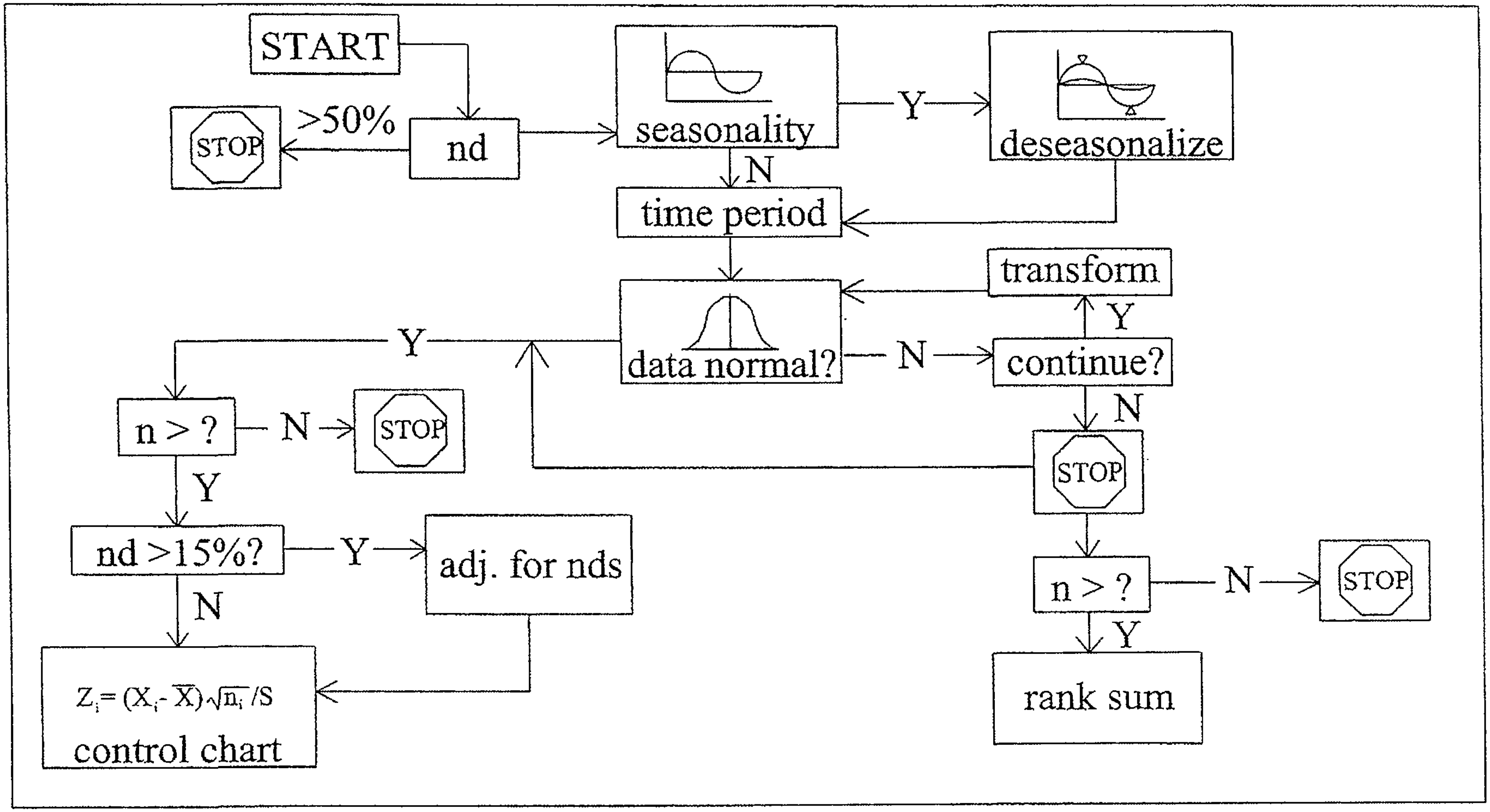
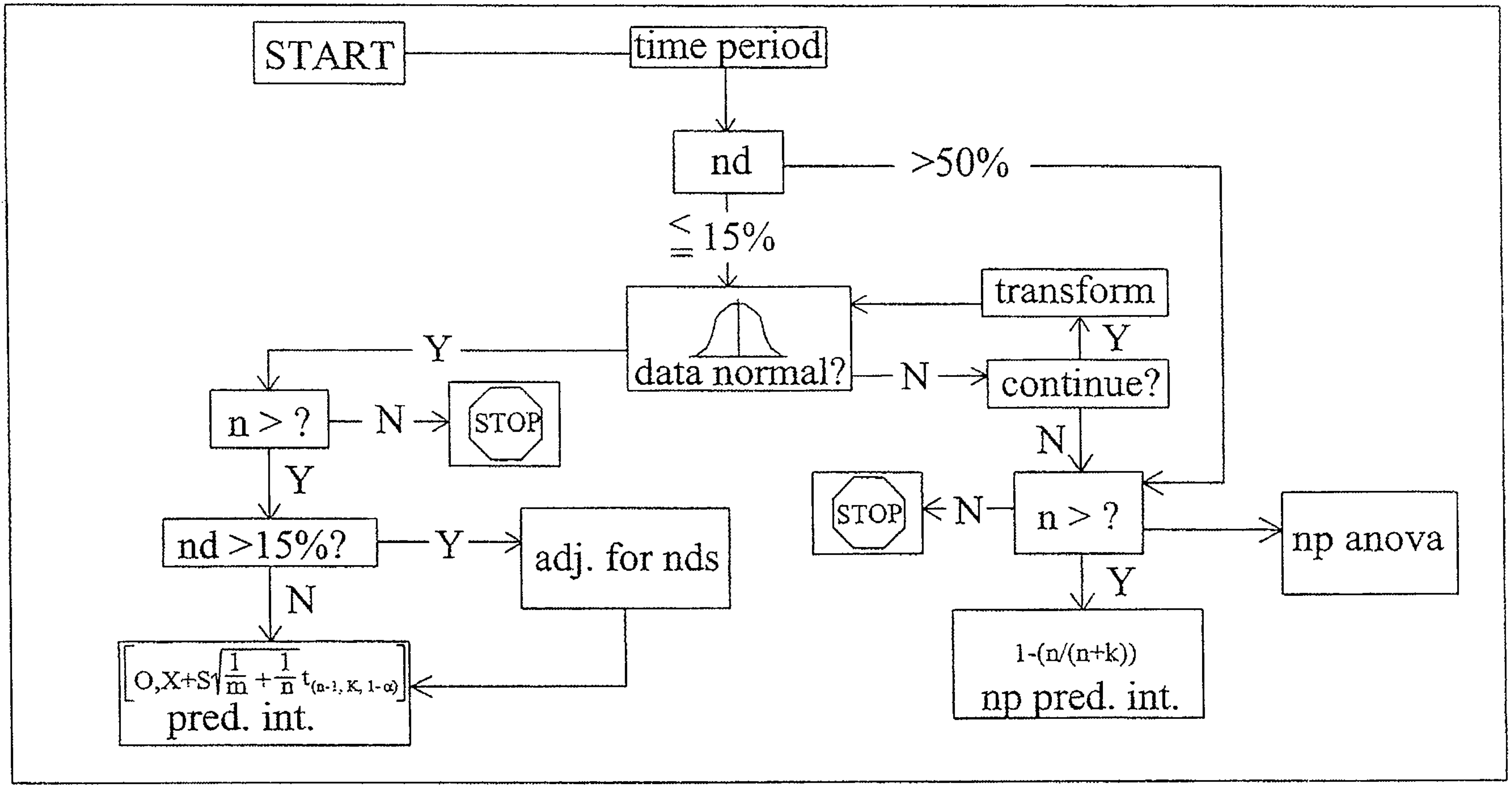
FIGURE E-1
CONTROL CHART FLOWCHART



Source: Sanitas™ version 7.5

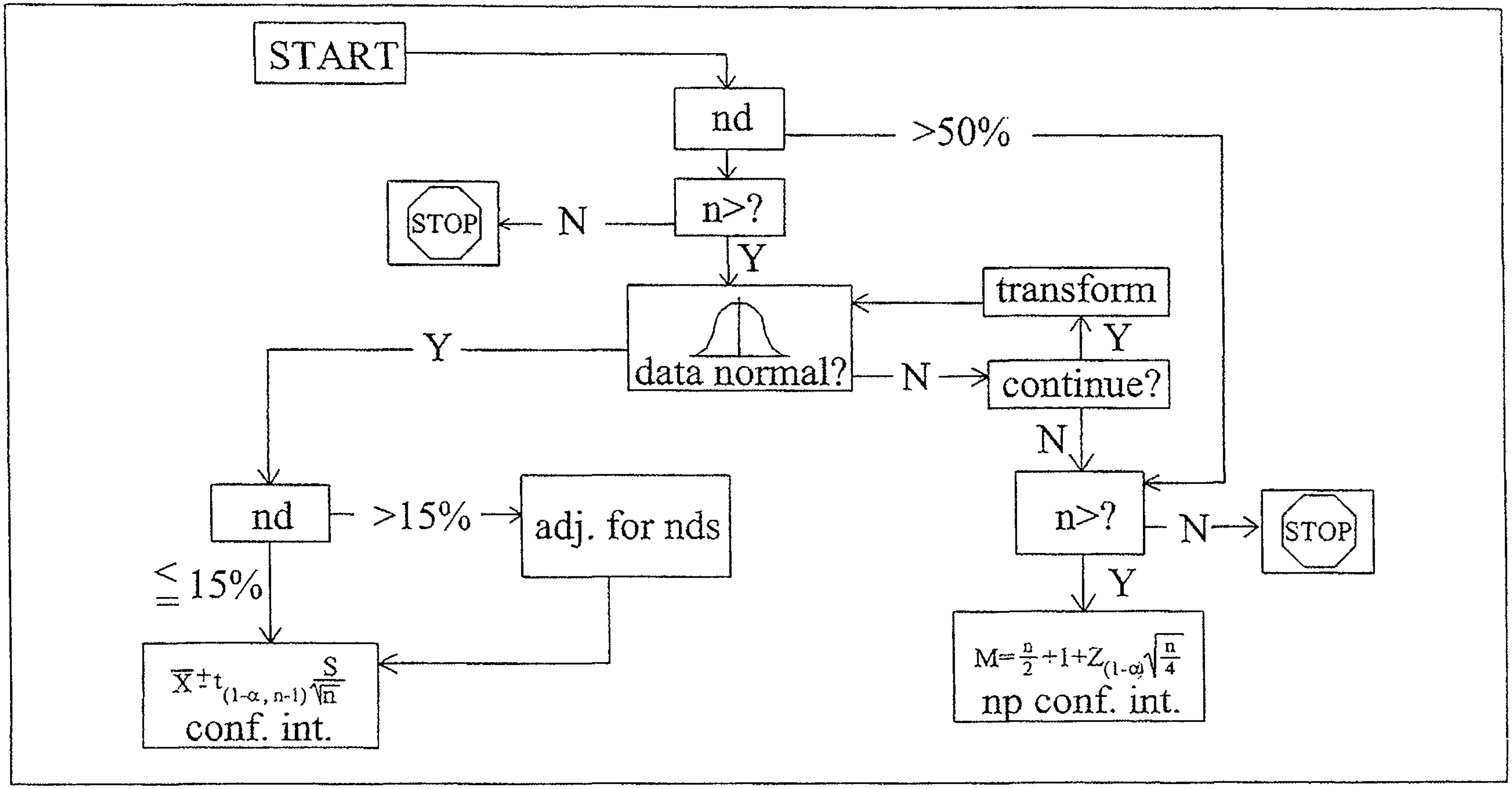
FIGURE E-2
PREDICTION LIMIT FLOWCHART



Source: Sanitas™ version 7.5

FIGURE E-3

95% CONFIDENCE INTERVAL FLOWCHART



Source: Sanitas™ version 8.0

APPENDIX C

CALIBRATION DATA SHEET

Calibration Data Sheet

Project:________________________________
Calibrated By:_____________________________
Date:__________________ **Time:**__________

Calibration Solution Temperature:_______ C

pH Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known pH	________________

Conductivity Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known Conductance	________________

Turbidity Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known Turbidity	________________

Date:__________________ **Time:**__________

Calibration Solution Temperature:_______ C

pH Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known pH	________________

Conductivity Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known Conductance	________________

Turbidity Meter

Model	________________
Serial Number	________________
Calibration Solution	________________
Instrument Reading	________________
Known Turbidity	________________

Comments:____
____

Applied Geotechnical Engineering Consultants, P.C.

RECEIVED
AUG 0 9 2005
H A & L

August 8, 2005

Hansen Allen & Luce, Inc.
6771 South 900 East
Midvale, UT 84047

Attention: Kent Staheli
FAX: 566-5581

Subject: Summary of Drilling and Completion of Borings
Wasatch Regional Solid Waste Landfill
Tooele County, Utah
AGEC Project No. 1040644

Gentlemen:

Applied Geotechnical Engineering Consultants, P.C. (AGEC) was requested to summarize the drilling and completion of borings for the Wasatch Regional Solid Waste Landfill to be located in Tooele County, Utah.

PREVIOUS STUDIES

AGEC previously conducted a geotechnical investigation (permit modification) for the Wasatch Regional Solid Waste Landfill and presented our findings and recommendations in a report dated June 15, 2005 under AGEC Project No. 1040644.

SUBSURFACE EXPLORATION

The subsurface conditions at the site were investigated by drilling five borings at the approximate locations indicated on Figure 1. Three of the borings were advanced to groundwater and PVC pipe was installed. The drilling extended down to a maximum depth of approximately 173 feet. Drilling was initially started using 8-inch diameter hollow-stem auger powered by an all-terrain drill rig. For the deeper exploration, and in more difficult drilling conditions, rotary methods using a 3½ inch diameter tricone bit was used with air as the circulation fluid.

The following table summarizes the approximate ground surface and subsurface water elevations, the boring depths and the depth of PVC pipe.

Boring Location	Approximate Ground Surface Elevation (ft)	Approximate Subsurface Water Elevation (ft)	Bottom Elevation of Boring (ft)	Bottom Elevation of PVC Pipe (ft)
B-1	4386.3	4232	4213	4223
B-2	4349.7	None to 4269	4269	Not Applicable
B-3	4249.1	4227	4213½	4214
B-4	4301.8	4225	4222	4222
B-5	4248.2	4226	4212½	4214

The approximate ground surface elevation was provided by representatives of Hansen Allen & Luce, Inc.

BORING COMPLETION

The PVC and backfill materials were installed through the 8-inch diameter hollow-stem augers used to advance the borings in Borings B-1, B-3, B-4 and B-5. No PVC pipe was installed in Boring B-2 due to the lack of water at the depth investigated. Slotted PVC pipe, 1½ inches in diameter, was installed in Boring B-4.

Slotted, 1½ inch diameter PVC pipe was installed in Boring B-4. The PVC pipe was slotted by hand sawing slots at random locations along the length of PVC pipe. The PVC pipe extends the full depth of the boring. The boring was backfilled with cuttings obtained from the boring advancement.

Generally, the boring completion construction was the same for Borings B-1, B-3 and B-5. A schematic showing the general details of the boring completion is presented on Figure 2. The PVC pipe installed consists of 2-inch diameter, Schedule 40 PVC pipe and a conical endcap (plug) was placed at the base. A 5-foot length of solid PVC pipe extends above the endcap (sump portion). Approximately 15 to 20 feet of machine slotted PVC pipe extends above the sump portions. The slots measure approximately 0.01 inches in width. The slotted PVC pipe portion was installed with the measured subsurface water level centered in the screened portion of the well. Solid PVC pipe extends from the screened portion of the well to the ground surface.

The PVC elements were seated on 10X20 silica sand. The borings were backfilled with silica sand from the bottom of the hole to approximately ½ to 8 feet above the screened portion of the PVC pipe. Bentonite chips with a maximum particle size of approximately ⅜ inch was used to backfill the remainder of the hole up to the ground surface.

	Boring Completion Depths		
Item	B-1	B-3	B-5
Depth of Boring, ft.	173	35½	35½
Solid PVC Pipe, ft.	0-138	0-14	0-14
Screened PVC Pipe, ft.	138-158	14-29	14-29
Solid PVC Pipe, ft.	158-163	29-34	29-34
Bentonite Backfill, ft.	0-130 and 163-173	0-11	0-13½
Silica Sand Backfill, ft.	130-163	11-34	13½-34

The borings were completed with the construction indicated above to be used as monitoring wells or piezometers as needed.

Each PVC pipe was secured with a locking PVC cap. A steel protective casing was placed above the portion of the PVC pipe which extends above the existing ground surface (approximately 2 to 3 feet). The protective cover was secured in place with a concrete pad which slopes away from the casing in all directions. A padlock secures each of the protective casings.

If you have any questions or if we can be of further service, please call.

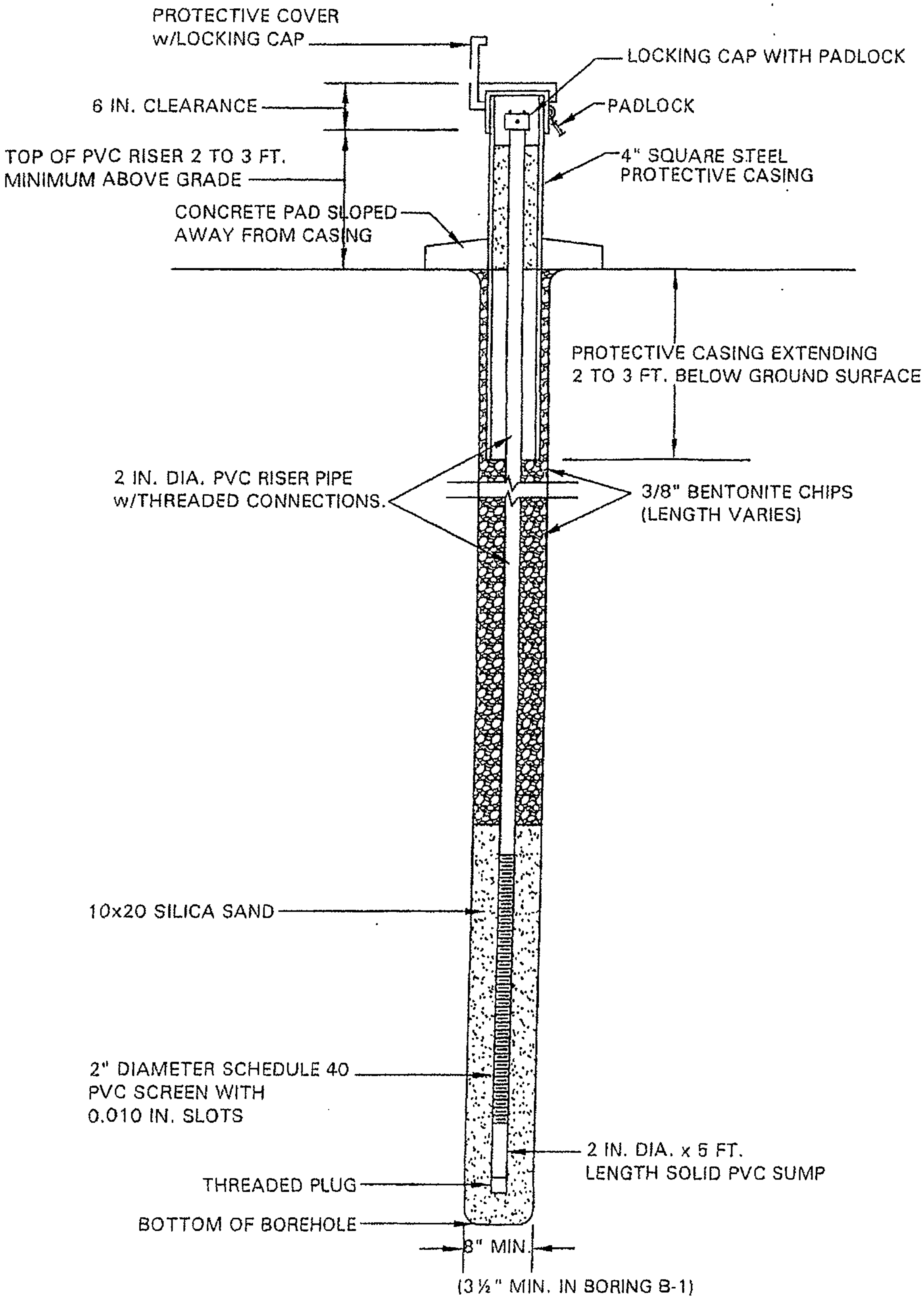
Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

Christopher J Beckman

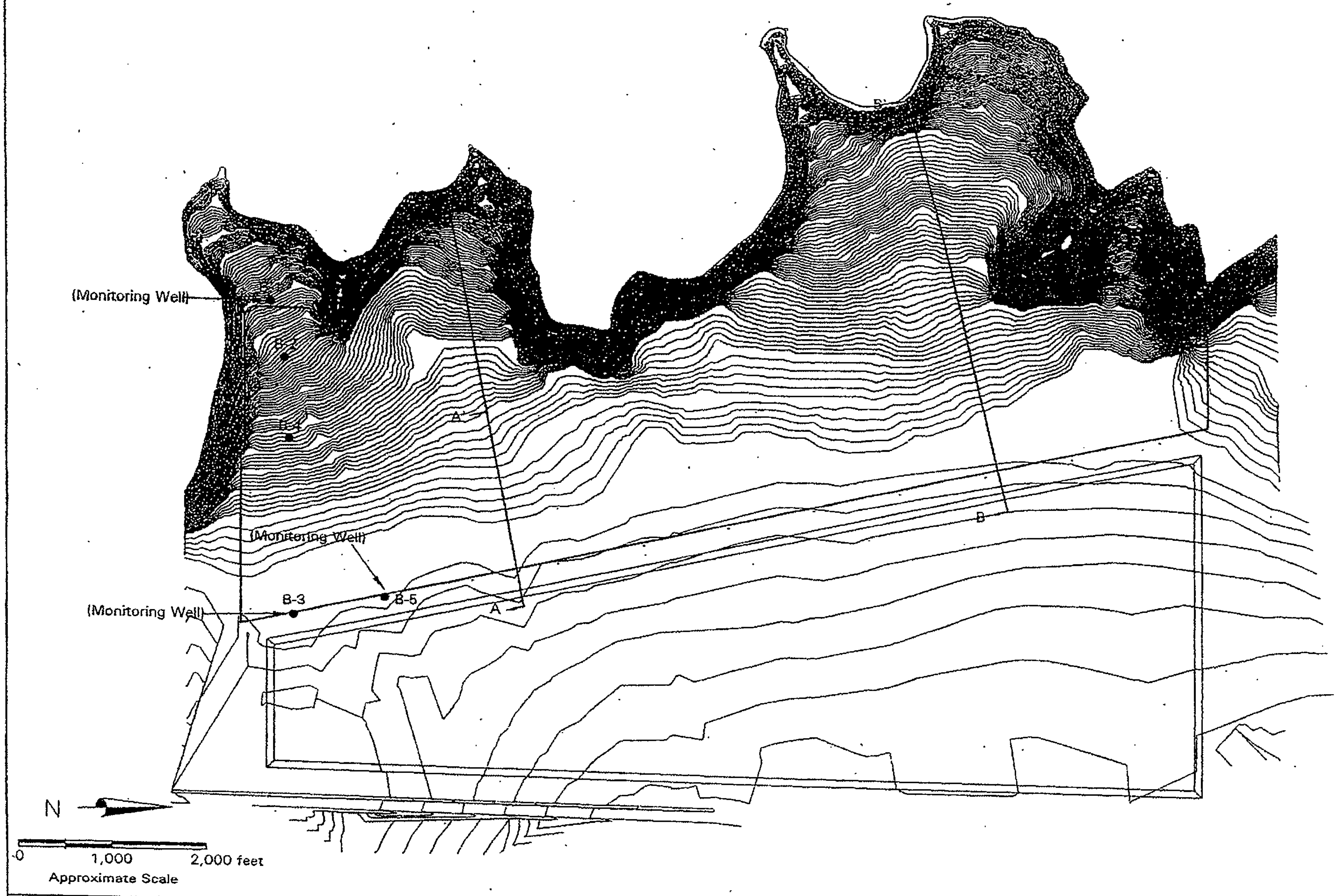
Christopher J. Beckman, P.E.

Reviewed by JEN, P.E.
CJB/dc
Enclosures



Note: Bentonite chips was placed below the PVC pipe in Boring B-1.

1040644	AGEC	Typical Boring Completion	Figure 2



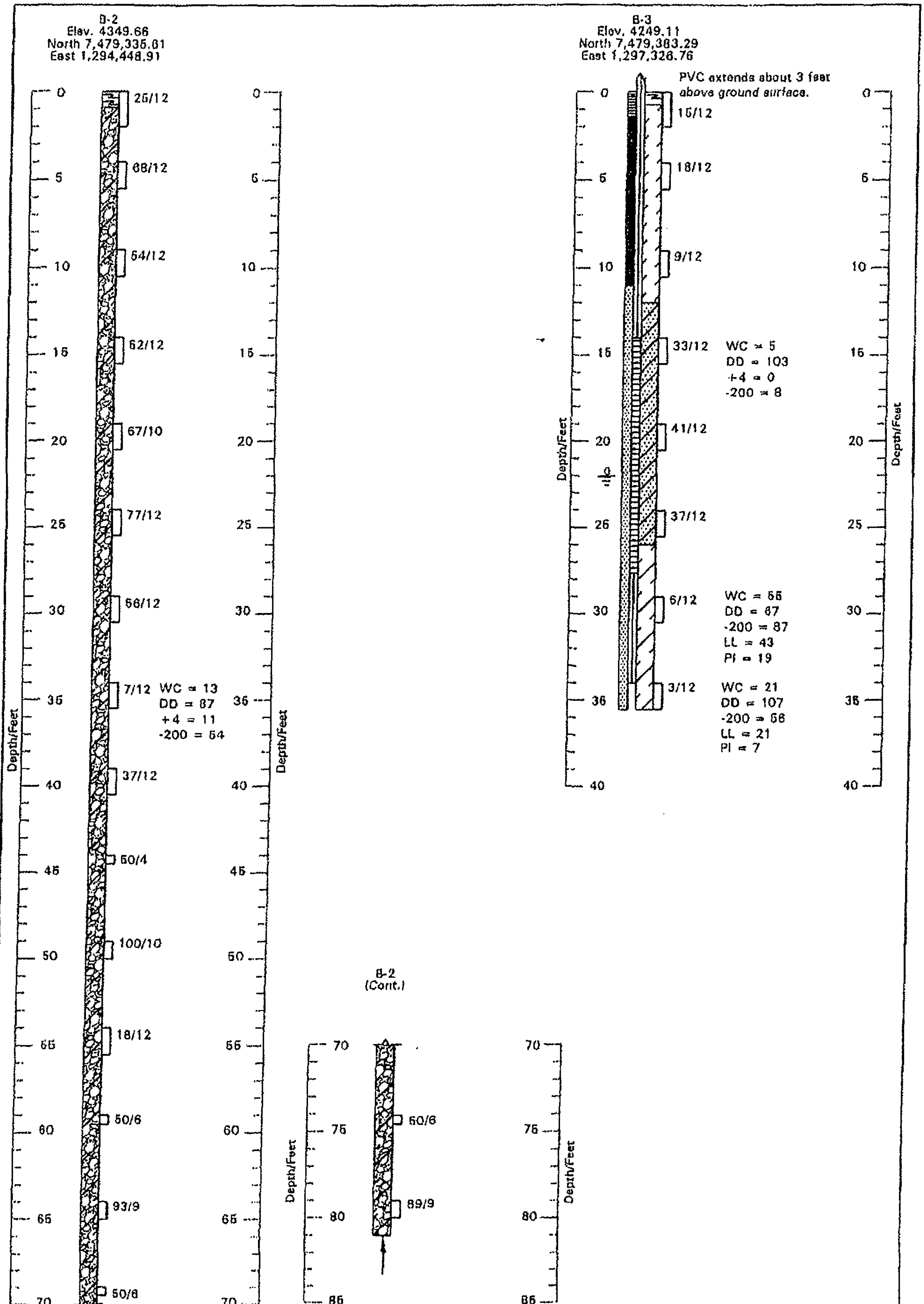
1040644	AGEC	Locations of Exploratory Borings

HANSEN ALLEN & LUCE inc.
CONSULTING ENGINEERS

SALT LAKE AREA OFFICE
6771 SOUTH 900 EAST
MIDVALE, UTAH 84047
Tel: (801) 566-5599
Fax: (801) 566-5581
Web Site: hansenallenluce.com

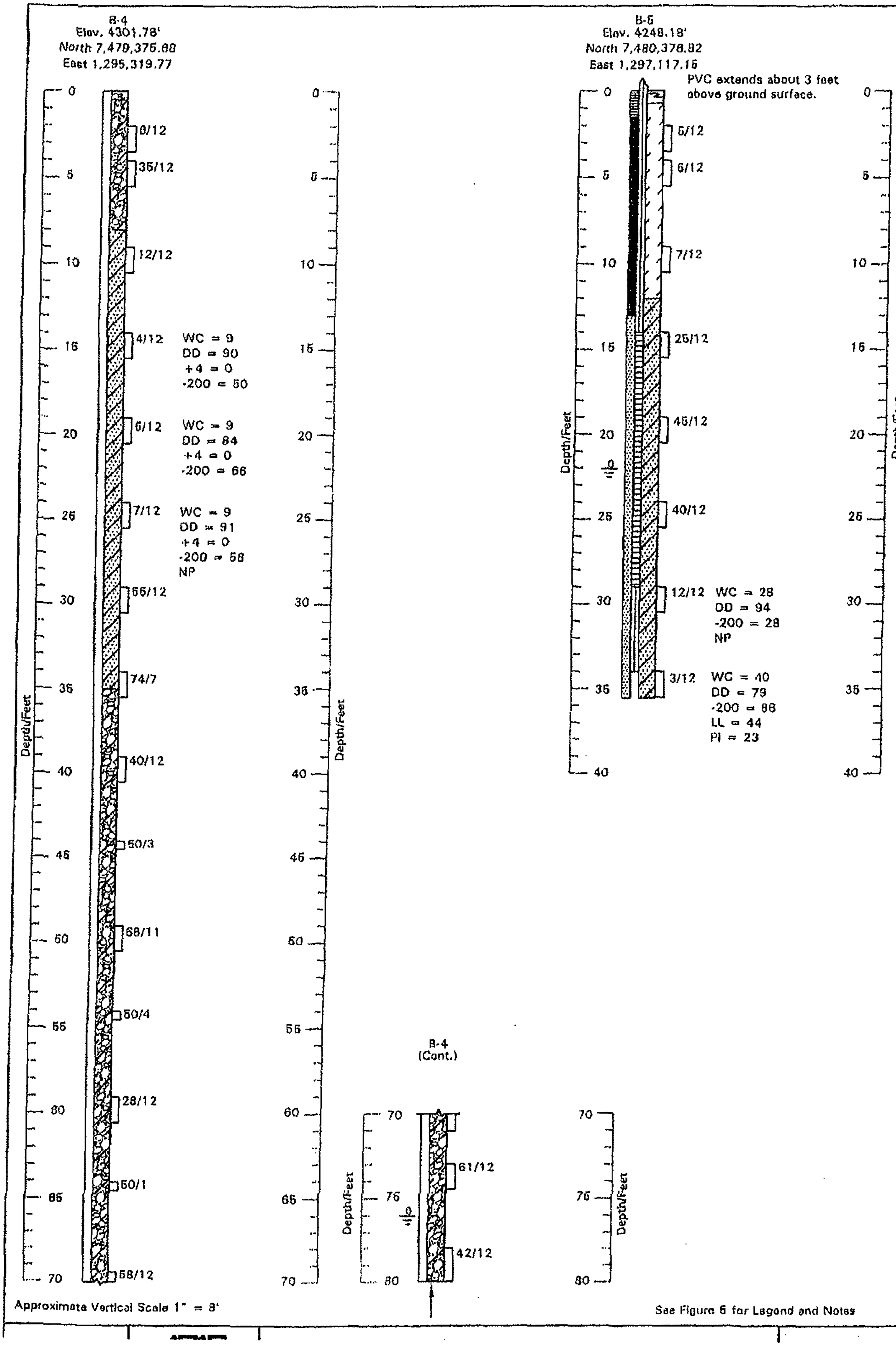
FACSIMILE TRANSMISSION

Page:	1 of 4
Date:	4-6-5
To:	Darin Olson
Firm/Agency:	ECDC
Fax Number:	435-888-0407
From:	Kent Staheli
HA&L Project No.:	113.30.106



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes


B-4
Elev. 4301.78'
North 7,479,375.88
East 1,295,319.77
8/12
35/12
12/12
4/12
WC = 9
DD = 90
+4 = 0
-200 = 50
6/12
WC = 9
DD = 84
+4 = 0
-200 = 66
7/12
WC = 9
DD = 91
+4 = 0
-200 = 58
NP
55/12
74/7
40/12
50/3
58/11
50/4
28/12
50/1
58/12
Depth/Feet
B-4
(Cont.)
61/12
42/12
B-5
Elev. 4248.18'
North 7,480,378.82
East 1,297,117.15
PVC extends about 3 feet above ground surface.
5/12
6/12
7/12
25/12
45/12
40/12
12/12
WC = 28
DD = 94
-200 = 28
NP
3/12
WC = 40
DD = 79
-200 = 86
LL = 44
PI = 23
Approximate Vertical Scale 1" = 8'
See Figure 6 for Legend and Notes

LEGEND:

Topsoil;

Lean Clay (CL); interlayered with sandy silt, stiff to very stiff, slightly moist to moist, brownish gray.

Silty Clay (CL-ML); sandy, medium to soft, wet, gray.

Sand (SM); silty, occassional lean clay layers, loose to dense, moist to wet, gray to grayish brown.

Gravel (GM/GC); sandy, silty and clayey, occassional cobble and boulders, medium to very dense, moist, brownish gray.

Gray Limestone

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates disturbed sample taken.

Indicates slotted 1½ inch PVC pipe installed in the boring to the depth shown.

0 Indicates the depth to free water and the number of days after drilling the measurement was taken.

Indicates screened portion of monitoring well. Screen slots 0.010 inches.

Indicates solid 2" diameter PVC pipe.

Indicates annular space backfilled with Portland Cement Concrete.

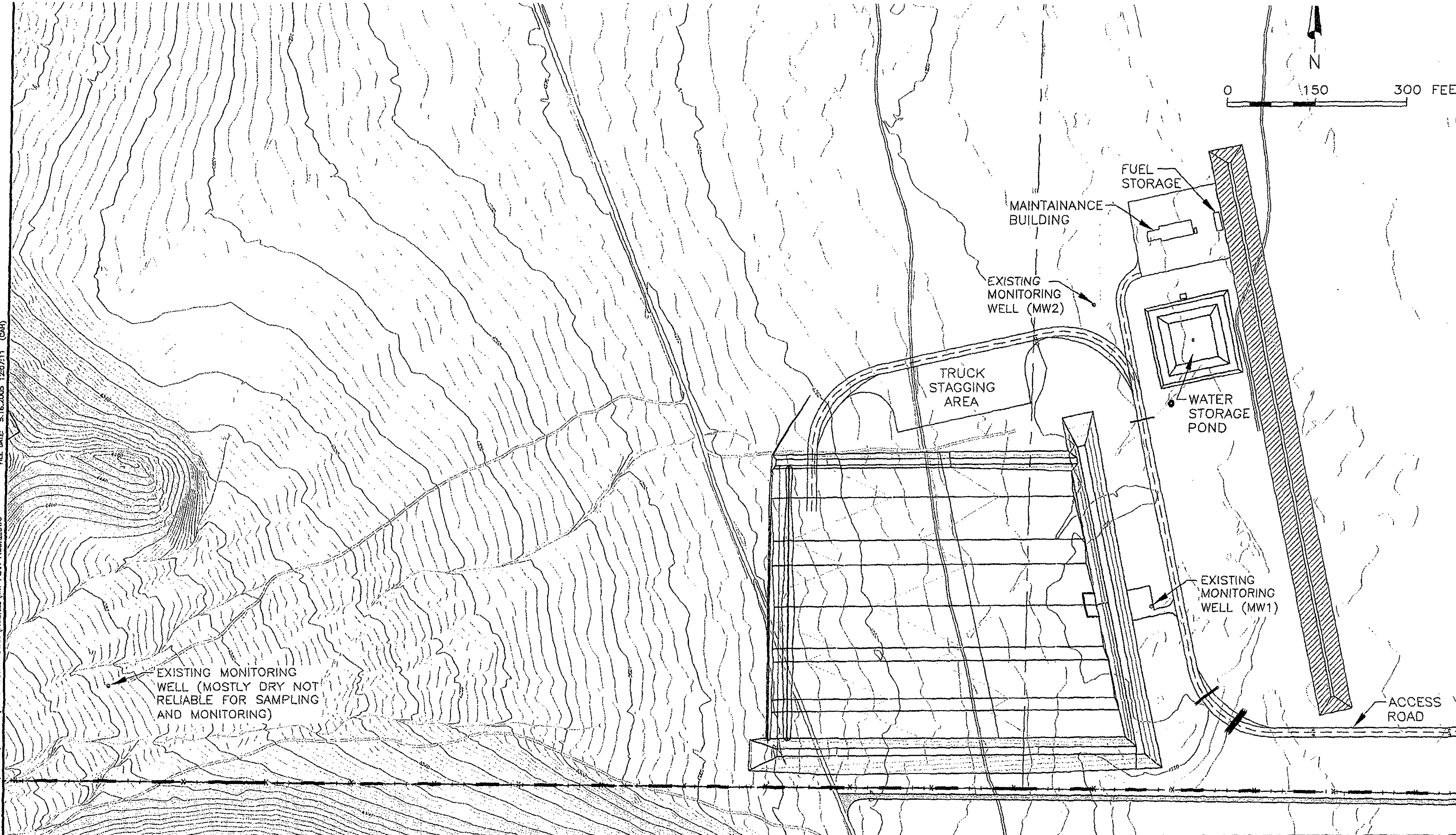
Indicates annular space backfilled with bentonite.

Indicates annular space backfilled with sand.

NOTES:

1. Borings were drilled on October 13, 14, 15, 18, 20, 21, 22, 25, 26, 27, 28 and 29, 2004 with 8-inch diameter hollow-stem auger and 3.5 inch tri-cone bit with air circulation.
2. Locations of borings were provided by civil engineer.
3. Elevations of borings were measured by civil engineer.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.
7. Monitor wells were completed with a 4 inch square steel locking cover set in a 2 foot square concrete slab. The 2-inch diameter PVC pipe protected by the well cover extends to approximately 3 feet above the ground surface.
8. WC = Water Content (%);
   DD = Dry Density (pcf);
   +4 = Percent Retained on No. 4 Sieve;
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   NP = Non Plastic

1040629	AGEC	Legend and Notes of Exploratory Borings	Figure 5



FILE NAME: 113\30.110\CADFILES\CONSTRUCTION DWGS\FIGURES\MW PLAN FIGURE.DWG FILE DATE: 5.16.2005 12:07:11 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS	WASATCH REGIONAL LANDFILL, INC.	PHASE 1A CONSTRUCTION MONITORING WELL PLAN	FIGURE 1

The Carel Corporation

Providing Environmental, Ground-Water and Waste Management Services

August 22, 2005
Project No.: 05-04-09

Mr. Dennis Downs, Executive Secretary
Utah Department of Environmental Quality (UDEQ)
Division of Solid and Hazardous Waste
288 North 1460 West
P.O. Box 144880
Salt Lake City, Utah 84114-4880

RE: Revised Pages for the Groundwater Sampling and Analysis Plan (GWSAP), Wasatch Regional Landfill

Dear Mr. Downs:

Following the August 18, 2005 submittal of the revised GWSAP for the Wasatch Regional Landfill, the UDEQ discovered a few inadvertent errors or omissions in Appendices B and D of the GWSAP. Appropriate revisions have been made to the incorrect pages. On behalf of Wasatch Regional Landfill, we are pleased to provide two copies of replacement pages for the facility GWSAP.

We trust this information is acceptable to you. Please feel free to call me with any questions you may have.

Sincerely,
THE CAREL CORPORATION

Steven Wimmer

Steven J. Wimmer
Geologist

Kevin T. Carel

Kevin T. Carel, P.G.
President

cc: Darin Olson, Allied Waste Industries

RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	*Container$_a$*	*Preservative*	*Holding Times*	*Reference*
Physical Properties					
Specific Cond. (Field)	100	P,G	None	Det. on Site	1
Specific Cond. (Lab)	100	P,G	Cool, 4 °C	28 Days	1
pH (Field)	50	P,G	None	Det. on Site	1,2
pH (Lab)	50	P,G	None	24 Hrs	1,2
Temperature	1000	P,G	None	Det. On Site	1
Turbidity	100	P,G	None	Det. On Site	1

Measurement	Volume (mL)	Container$_a$	Preservative	Holding Times	Reference
Inorganics, Non-Metallics					
Carbonate/Bicarbonate	200	P,G	Cool, 4 °C	14 days	1
Chloride	200	P,G	None	28 Days	1,2
Nitrate plus Nitrite	200	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	1,2
COD	50	P,G	H_2SO_4 to pH <2	28 days	1
Sulfate	100	P,G	Cool, 4 °C	28 days	1,2
Ammonia as Nitrogen	1000	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	2,3
Total Dissolved Solids (TDS)	500	P,G	Cool, 4 °C	7 days	2,3
Total Organic Carbon (TOC)	250	P,G	Cool, 4 °C HCL or H_2SO_4 to pH <2	28 days	2,3

The Sen's Slope estimator portion of the combined method provides an estimate of the true slope. The method is a non-parametric procedure not greatly affected by gross data errors or outliers, and can be computed when data are missing.

2.2 Statistical Evaluation of Volatile Organic Compounds

Volatile organic compounds (VOCs) will be routinely monitored during the detection monitoring program. The statistical limit for VOCs detected in wells under detection monitoring will be set equal to the laboratory reporting limit (RL). RLs are provided in Table 1 of the facility's Groundwater Sampling and Analysis Plan (GWSAP). As with the prediction limit statistical method, VOC detections will not be considered statistically significant unless confirmed by verification resampling. Verification resampling procedures are provided in Section 2.3 and in the GWSAP.

2.3 Verification Resampling

Results for constituents that exceed statistical limits will not be considered statistically significant unless they are confirmed through verification resampling.

If a statistically significant change (SSC) from background of any tested constituent at any monitor well has occurred (i.e. is confirmed) and there is reasonable cause that a source other than the landfill exists, then a report will be submitted documenting the source as per Section 5.1 of the GWSAP and UAC R315-308-2 (10)(c). Otherwise, assessment monitoring will be implemented in accordance with Section 5.1 of the GWSAP and UDEQ regulations.

3 ASSESSMENT MONITORING STATISTICAL ANALYSIS

For assessment wells, constituents exceeding detection monitoring statistical limits and that have a groundwater protection standard (GWPS) established by the USEPA or the UDEQ, and/or any VOC detections will be statistically compared to GWPS using one-sided 95-percent lower confidence limits (LCL). Evaluations are conducted per Gibbons and Coleman (2001). The method constructs a normal confidence interval on the mean concentration of a constituent incorporating, at a minimum, the four most recent semi-annual measurements. A separate interval is constructed for each constituent of interest in each well of interest. A confidence interval is generally used when downgradient samples are being compared to a Groundwater Protection Standard (GWPS). A flow chart depicting the decision making process during the analysis is provided as Figure E-3.

The lower 95-percent confidence limit on the mean will be compared to a GWPS to decide initially whether the mean concentration of a constituent of interest has exceeded a GWPS. If the lower 95-percent confidence limit on the mean exceeds the GWPS then there is statistically significant evidence that the mean concentration of that constituent exceeds the GWPS. Upper 95-percent confidence limit analyses may be applied to constituents in which it's 95 percent LCL has exceeded a GWPS. If the upper 95-percent confidence limit on the mean occurs lower that the GWPS then there is statistically significant evidence that the mean concentration of that constituent has returned to less than the GWPS.

3.1 Assumptions

The sample data used to construct the limits must be normally or transformed-normally distributed. In the case of a transformed-normal distribution, the confidence limit must be constructed on the transformed sample concentration values. In addition to the limit construction, the comparison must be made to the transformed GWPS value. When none of the transformed models can be justified, a nonparametric version of each limit may be utilized.

The Carel Corporation

Providing Environmental, Ground-Water and Waste Management Services

June 26, 2006
Project No: 06-06-32

Mr. Dennis Downs, Executive Secretary
Utah Department of Environmental Quality (UDEQ)
Division of Solid and Hazardous Waste
288 North 1460 West
P.O. Box 144880
Salt Lake City, Utah 84114-4880

Re: Groundwater Sampling and Analysis Plan (GWSAP) - Table 1 Revision; Wasatch Regional Landfill; Tooele County, Utah

Dear Mr. Downs:

Wasatch

On behalf of the ~~Washington~~ County Landfill, we are including a revised GWSAP Table 1 replacement page. Per a UDEQ request, a revised GWSAP Table 1 replacement page was submitted on March 10, 2006. The UDEQ requested the change because of an error on the CAS number for trans-1,3-dichloropropene which was subsequently corrected. However, the CAS number was inadvertently corrected on an older version of the GWSAP Table 1. The CAS number has been corrected on the final version of the GWSAP Table 1 (completed in August 2005) and the revised replacement page is included in Attachment 1 of this letter. Please discard the replacement page amended in March 2006 and substitute with the replacement page attached to this letter.

We trust that this information is acceptable to you. Two copies of this document are provided for your use and distribution. Please call if you have any questions.

Sincerely,
THE CAREL CORPORATION

Steven Wim

Steven J. Wimmer
Geologist

Kevin T. Carel

Kevin T. Carel, P.G.
President

Attachment 1 – GWSAP Table 1 – Replacement Page

cc: Darin Olson – Allied Waste Industries

ATTACHMENT 1

GWSAP Table 1 Replacement Page

Table 1 (Continued)

Heavy Metals	CAS	Method[1]	RL[2] (mg/L)
Vanadium	7440-62-2	6010 or 7911	0.02
Zinc	7440-66-6	6010 or 6020	0.01

Volatile Organic Compounds	CAS	Method[1]	RL[2] (µg/L)
Acetone	67-64-1	8260B	10
Acrylonitrile	107-13-1	8260B	50
Benzene	71-43-2	8260B	4
Bromochloromethane	74-97-5	8260B	4
Bromodichloromethane	75-27-4	8260B	4
Bromoform (tribromomethane)	75-25-2	8260B	4
Carbon disulfide	75-15-0	8260B	4
Carbon tetrachloride	56-23-5	8260B	4
Chlorobenzene	108-90-7	8260B	4
Chloroethane (ethyl chloride)	75-00-3	8260B	8
Chloroform (trichloromethane)	67-66-3	8260B	4
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8260B	4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260B	0.2
1,2-Dibromoethane (ethylene dibromide, EDB)	106-93-4	8260B	0.05
o-Dichlorobenzene (1,2-dichlorobenzene)	95-50-1	8260B	4
p-Dichlorobenzene (1,4 dichlorobenzene)	106-46-7	8260B	4
trans-1,4-Dichloro-2-butene	110-57-6	8260B	4
1,1-Dichloroethane (ethylidene chloride)	75-34-3	8260B	4
1,2-Dichloroethane (ethylene dichloride)	107-06-2	8260B	4
1,1-Dichloroethylene (1,1-dichloroethene)	75-35-4	8260B	4
cis-1,2-Dichloroethylene (1,1-dichloroethene)	156-59-2	8260B	4
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	156-60-5	8260B	4
1,2-Dichloropropane (propylene dichloride)	78-87-5	8260B	4
cis-1,3-dichloropropene	10061-01-5	8260B	2
trans-1,3-dichloropropene	10061-02-6	8260B	2

Value Cell	Sub Cell	Company	Cell/Service Description	Califormia
Civil Engineering	Heap Leach Facilities Tailings Storage Facilities Landfills Impoundments Infrastructure/Public Facilities Energy Facilities	Vector GV	Services include hydrology and hydraulics, site grading and drainage control, road design, containment system design (liner systems and leachate collection and removal systems), geosynthetics design, final cover system design, leachate management, soil stabilization, conveyance design, water balance analysis. Facility master planning, closure and end use planning and design, site development phasing. New facilities, horizontal and vertical expansions, closures. PFS through Detailed Engineering. Construction-level documents including plans, technical specifications, const estimate and CQA Plans. Permitting and compliance documentation, new permits and permit modifications/revisions. Broad geographic base.	**14**
Geotechnical Engineering	Heap Leach Facilities Tailings Storage Facilities Landfills Impoundments Infrastructure/Public Facilities Energy Facilities	Vector GV	Services include site characterization, borrow characterization, geotechnics (subsurface, heap leach pile, embankments, liner systems) analysis and design, geology and seismicity analysis and characterization, materials testing, dewatering and seepage analysis, soil stabilization and reinforcement analysis and design, retainining and tie-back systems, optimization, forensics. PFS through Detailed Engineering. Broad geographic base. Value Engineering, constructability and Peer Reviews.	**7**
Geological Services	Heap Leach Facilities Tailings Storage Facilities Landfills Impoundments Infrastructure/Public Facilities Energy Facilities	Vector GV	Services include geologic characterization, surface mapping, seismicity analysis and characterization, fault investigations, groundwater and vadose zone analyses, forensics. PFS through Detailed Engineering. Broad geographic base.	**1**
Mine Engineering	Surface Metal / Non-metal	Vector GV	High rock slope geotechnical engineering design, rock mass characterization, state and federal permitting, environmental assessment, aggregate resource estimation, transportation and equipment studies, hazard assessment, 43-101 and JORC qualified for precious metals and nickel, ore control and operations auditing, mine planning.	**1**
Landfill Gas and Bio Gas	Landfills Agricultural Facilities	Vector GV	Services include LFG extraction and collection systems, treatment systems, condensate collection systems, monitoring systems. Planning, design, construction quality assurance, operations & maintenance. LFG generation analyses. Monitoring and migration evaluation and mitigation.	**2**
Construction Support	Heap Leach Facilities Tailings Storage Facilities Landfills Impoundments Infrastructure/Public Facilities Energy Facilities	Vector GV	Services include construction quality assurance testing and oversight, engineering support, geoelectric leak testing of geomembranes. Groundwater monitoring well installation and testing, landfill gas monitoring probe installation and testing. Forensics. Broad geographic base.	**15**
Materials Testing		Vector GV	7000 sq ft materials testing laboratory specialising in soils, rock, concrete, asphalt, tailings and geosynthetics testing. One of the largest laboratories in California with multiple agency certifications.	**20**

APPENDIX 4.8
HELP Model Data

```
0
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**             DEVELOPED BY ENVIRONMENTAL LABORATORY                        **
**             USAE WATERWAYS EXPERIMENT STATION                            **
**         FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\TEMP\HELP\DATA4.D4
TEMPERATURE DATA FILE:        C:\TEMP\HELP\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\TEMP\HELP\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\TEMP\HELP\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\TEMP\HELP\BORIS.D10
OUTPUT DATA FILE:             C:\TEMP\HELP\TEST.OUT


TIME:  16:53     DATE:  10/ 4/2004


******************************************************************************

    TITLE:  WASATCH REGIONAL LANDFILL

******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
           COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  10
        THICKNESS                  =    24.00   INCHES
        POROSITY                   =     0.3980 VOL/VOL
        FIELD CAPACITY             =     0.2440 VOL/VOL
        WILTING POINT              =     0.1360 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.1693 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
            FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                 LAYER  2
                                 --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                      MATERIAL TEXTURE NUMBER  20
        THICKNESS                  =     0.25   INCHES
        POROSITY                   =     0.8500 VOL/VOL
        FIELD CAPACITY             =     0.0100 VOL/VOL
        WILTING POINT              =     0.0050 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.1296 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  10.0000000000     CM/SEC
        SLOPE                      =     2.00   PERCENT
        DRAINAGE LENGTH            =   250.0    FEET


                                 LAYER  3
                                 --------

                    TYPE 4 - FLEXIBLE MEMBRANE LINER
                      MATERIAL TEXTURE NUMBER  35
        THICKNESS                  =     0.06   INCHES
        POROSITY                   =     0.0000 VOL/VOL
        FIELD CAPACITY             =     0.0000 VOL/VOL
        WILTING POINT              =     0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
        FML PINHOLE DENSITY        =     0.00   HOLES/ACRE
        FML INSTALLATION DEFECTS   =     0.00   HOLES/ACRE
        FML PLACEMENT QUALITY      =  4 - POOR


                                 LAYER  4
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                     TYPE 3 - BARRIER SOIL LINER
                      MATERIAL TEXTURE NUMBER  17
        THICKNESS                  =     0.60   INCHES
        POROSITY                   =     0.7500 VOL/VOL
        FIELD CAPACITY             =     0.7470 VOL/VOL
        WILTING POINT              =     0.4000 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.7500 VOL/VOL
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EFFECTIVE SAT. HYD. COND.     =  0.300000003000E-08 CM/SEC


                         LAYER  5
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             TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   9
THICKNESS                      =     12.00    INCHES
POROSITY                       =      0.5010 VOL/VOL
FIELD CAPACITY                 =      0.2840 VOL/VOL
WILTING POINT                  =      0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.2840 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.190000006000E-03 CM/SEC


                         LAYER  6
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             TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  18
THICKNESS                      =   1140.00    INCHES
POROSITY                       =      0.6710 VOL/VOL
FIELD CAPACITY                 =      0.2920 VOL/VOL
WILTING POINT                  =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                         LAYER  7
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             TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  10
THICKNESS                      =     18.00    INCHES
POROSITY                       =      0.3980 VOL/VOL
FIELD CAPACITY                 =      0.2440 VOL/VOL
WILTING POINT                  =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.119999997000E-03 CM/SEC


                         LAYER  8
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               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  20
THICKNESS                      =      0.25    INCHES
POROSITY                       =      0.8500 VOL/VOL
FIELD CAPACITY                 =      0.0100 VOL/VOL
WILTING POINT                  =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  10.0000000000     CM/SEC
SLOPE                          =      2.00    PERCENT
DRAINAGE LENGTH                =    250.0     FEET


                         LAYER  9
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              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                      =      0.06    INCHES
POROSITY                       =      0.0000 VOL/VOL
FIELD CAPACITY                 =      0.0000 VOL/VOL
WILTING POINT                  =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS       =      1.00    HOLES/ACRE
FML PLACEMENT QUALITY          =  2 - EXCELLENT


                         LAYER 10
                         --------

                 TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  17
THICKNESS                      =      0.60    INCHES
POROSITY                       =      0.7500 VOL/VOL
FIELD CAPACITY                 =      0.7470 VOL/VOL
WILTING POINT                  =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.300000003000E-08 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
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NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.
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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.81	14415096.000	100.00
RUNOFF	0.079	88373.344	0.61
EVAPOTRANSPIRATION	12.994	14621979.000	101.44
DRAINAGE COLLECTED FROM LAYER 2	0.0750	84406.375	0.59
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.190	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.107	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.083	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.337	-379651.219	-2.63
SOIL WATER AT START OF YEAR	345.675	388987616.000	
SOIL WATER AT END OF YEAR	345.469	388755744.000	
SNOW WATER AT START OF YEAR	0.131	147777.891	1.03
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-12.196	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.47	9531293.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.288	9326715.000	97.85
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.182	204569.281	2.15
SOIL WATER AT START OF YEAR	345.469	388755744.000	
SOIL WATER AT END OF YEAR	344.895	388110080.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.756	850222.500	8.92
ANNUAL WATER BUDGET BALANCE	0.0000	9.055	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.97	16845748.000	100.00
RUNOFF	0.180	202250.281	1.20
EVAPOTRANSPIRATION	14.656	16492197.000	97.90
DRAINAGE COLLECTED FROM LAYER 2	0.1453	163548.625	0.97
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.208	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.117	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.090	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		

RUNOFF	0.011	12196.894	0.09
EVAPOTRANSPIRATION	12.612	14192809.000	103.04
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.383	-431346.469	-3.13
SOIL WATER AT START OF YEAR	345.246	388505760.000	
SOIL WATER AT END OF YEAR	345.026	388258208.000	
SNOW WATER AT START OF YEAR	0.601	675905.562	4.91
SNOW WATER AT END OF YEAR	0.437	492126.437	3.57
ANNUAL WATER BUDGET BALANCE	0.0000	13.497	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.97	11219242.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.734	10953468.000	97.63
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.236	265771.469	2.37
SOIL WATER AT START OF YEAR	345.026	388258208.000	
SOIL WATER AT END OF YEAR	345.607	388911744.000	
SNOW WATER AT START OF YEAR	0.437	492126.437	4.39
SNOW WATER AT END OF YEAR	0.093	104346.172	0.93
ANNUAL WATER BUDGET BALANCE	0.0000	3.287	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.07	15832975.000	100.00
RUNOFF	0.340	382364.156	2.41
EVAPOTRANSPIRATION	14.102	15868696.000	100.23
DRAINAGE COLLECTED FROM LAYER 2	0.0951	107004.844	0.68
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.177	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0009		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.100	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.077	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.467	-525097.375	-3.32
SOIL WATER AT START OF YEAR	345.607	388911744.000	
SOIL WATER AT END OF YEAR	345.233	388491008.000	
SNOW WATER AT START OF YEAR	0.093	104346.172	0.66

PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.691	-777270.750	-6.43
SOIL WATER AT START OF YEAR	345.708	389024800.000	
SOIL WATER AT END OF YEAR	344.913	388131040.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.104	116499.359	0.96
ANNUAL WATER BUDGET BALANCE	0.0000	13.270	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.08	12468327.000	100.00
RUNOFF	0.040	45567.332	0.37
EVAPOTRANSPIRATION	10.347	11643449.000	93.38
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.693	779308.250	6.25
SOIL WATER AT START OF YEAR	344.913	388131040.000	
SOIL WATER AT END OF YEAR	345.675	388988160.000	
SNOW WATER AT START OF YEAR	0.104	116499.359	0.93
SNOW WATER AT END OF YEAR	0.034	38679.840	0.31
ANNUAL WATER BUDGET BALANCE	0.0000	2.369	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.47	12907193.000	100.00
RUNOFF	0.001	1501.367	0.01
EVAPOTRANSPIRATION	11.592	13044453.000	101.06
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.123	-138753.656	-1.08
SOIL WATER AT START OF YEAR	345.675	388988160.000	
SOIL WATER AT END OF YEAR	345.209	388463392.000	
SNOW WATER AT START OF YEAR	0.034	38679.840	0.30
SNOW WATER AT END OF YEAR	0.377	424697.594	3.29
ANNUAL WATER BUDGET BALANCE	0.0000	-7.192	0.00

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AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.847	952644.312	7.37
SOIL WATER AT START OF YEAR	345.815	389145952.000	
SOIL WATER AT END OF YEAR	346.300	389691648.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.362	406958.969	3.15
ANNUAL WATER BUDGET BALANCE	0.0000	-15.209	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.95	14572637.000	100.00
RUNOFF	0.416	468087.937	3.21
EVAPOTRANSPIRATION	12.559	14132915.000	96.98
DRAINAGE COLLECTED FROM LAYER 2	0.5300	596362.125	4.09
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.423	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0051		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.242	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.182	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.555	-624718.000	-4.29
SOIL WATER AT START OF YEAR	346.300	389691648.000	
SOIL WATER AT END OF YEAR	346.107	389473888.000	
SNOW WATER AT START OF YEAR	0.362	406958.969	2.79
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-10.920	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.44	8372232.000	100.00
RUNOFF	0.118	133271.453	1.59
EVAPOTRANSPIRATION	7.823	8803018.000	105.15
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.501	-564068.312	-6.74
SOIL WATER AT START OF YEAR	346.107	389473888.000	
SOIL WATER AT END OF YEAR	345.386	388662944.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.219	246870.203	2.95
ANNUAL WATER BUDGET BALANCE	0.0000	10.472	0.00

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ANNUAL TOTALS FOR YEAR 20

SOIL WATER AT END OF YEAR	345.665	388976960.000	
SNOW WATER AT START OF YEAR	0.114	127844.250	0.86
SNOW WATER AT END OF YEAR	0.902	1014564.120	6.84
ANNUAL WATER BUDGET BALANCE	0.0000	12.450	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.82	18927554.000	100.00
RUNOFF	0.472	531447.937	2.81
EVAPOTRANSPIRATION	16.468	18531570.000	97.91
DRAINAGE COLLECTED FROM LAYER 2	0.5884	662100.375	3.50
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.407	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0059		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.231	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.175	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.709	-797548.937	-4.21
SOIL WATER AT START OF YEAR	345.665	388976960.000	
SOIL WATER AT END OF YEAR	345.801	389129696.000	
SNOW WATER AT START OF YEAR	0.902	1014564.120	5.36
SNOW WATER AT END OF YEAR	0.057	64298.805	0.34
ANNUAL WATER BUDGET BALANCE	0.0000	-15.137	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.66	14246304.000	100.00
RUNOFF	0.052	58645.664	0.41
EVAPOTRANSPIRATION	11.774	13249072.000	93.00
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.834	938576.875	6.59
SOIL WATER AT START OF YEAR	345.801	389129696.000	
SOIL WATER AT END OF YEAR	346.495	389911232.000	
SNOW WATER AT START OF YEAR	0.057	64298.805	0.45
SNOW WATER AT END OF YEAR	0.197	221333.406	1.55
ANNUAL WATER BUDGET BALANCE	0.0000	9.675	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.93	13424831.000	100.00
RUNOFF	0.273	306942.969	2.29
EVAPOTRANSPIRATION	12.254	13789573.000	102.72

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.65	15360351.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.680	13143606.000	85.57
DRAINAGE COLLECTED FROM LAYER 2	0.3312	372725.125	2.43
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.217	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0032		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.105	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.112	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	1.639	1844024.120	12.01
SOIL WATER AT START OF YEAR	345.927	389271712.000	
SOIL WATER AT END OF YEAR	347.651	391211808.000	
SNOW WATER AT START OF YEAR	0.368	414138.437	2.70
SNOW WATER AT END OF YEAR	0.283	318077.812	2.07
ANNUAL WATER BUDGET BALANCE	0.0000	-4.778	0.00

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.69	15405363.000	100.00
RUNOFF	0.146	163752.328	1.06
EVAPOTRANSPIRATION	14.591	16419608.000	106.58
DRAINAGE COLLECTED FROM LAYER 2	1.4452	1626294.750	10.56
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.912	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0139		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.633	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.279	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-2.492	-2804328.750	-18.20
SOIL WATER AT START OF YEAR	347.651	391211808.000	
SOIL WATER AT END OF YEAR	345.442	388725568.000	
SNOW WATER AT START OF YEAR	0.283	318077.812	2.06
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	35.492	0.00

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.22	11500567.000	100.00
RUNOFF	0.040	45045.742	0.39
EVAPOTRANSPIRATION	10.208	11487089.000	99.88
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		

ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.61	13064737.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.412	12841844.000	98.29
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.198	222884.578	1.71
SOIL WATER AT START OF YEAR	345.558	388856640.000	
SOIL WATER AT END OF YEAR	345.651	388961024.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.105	118486.633	0.91
ANNUAL WATER BUDGET BALANCE	0.0000	8.476	0.00

ANNUAL TOTALS FOR YEAR 34

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.75	12096975.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.889	12253101.000	101.29
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.139	-156124.828	-1.29
SOIL WATER AT START OF YEAR	345.651	388961024.000	
SOIL WATER AT END OF YEAR	345.618	388923392.000	
SNOW WATER AT START OF YEAR	0.105	118486.633	0.98
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.964	0.00

ANNUAL TOTALS FOR YEAR 35

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.68	15394105.000	100.00
RUNOFF	0.075	84326.164	0.55
EVAPOTRANSPIRATION	13.825	15557609.000	101.06
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.220	-247807.766	-1.61

RUNOFF	0.122	137558.141	1.21
EVAPOTRANSPIRATION	9.809	11037680.000	97.31
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.149	167769.281	1.48
SOIL WATER AT START OF YEAR	345.261	388522624.000	
SOIL WATER AT END OF YEAR	345.315	388583040.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.095	107362.695	0.95
ANNUAL WATER BUDGET BALANCE	0.0000	16.198	0.00

ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.89	16755717.000	100.00
RUNOFF	0.358	403112.750	2.41
EVAPOTRANSPIRATION	13.825	15557646.000	92.85
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.706	794965.625	4.74
SOIL WATER AT START OF YEAR	345.315	388583040.000	
SOIL WATER AT END OF YEAR	345.960	389308224.000	
SNOW WATER AT START OF YEAR	0.095	107362.695	0.64
SNOW WATER AT END OF YEAR	0.157	177140.328	1.06
ANNUAL WATER BUDGET BALANCE	0.0000	-6.741	0.00

ANNUAL TOTALS FOR YEAR 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.19	13717407.000	100.00
RUNOFF	0.015	17418.125	0.13
EVAPOTRANSPIRATION	13.197	14850858.000	108.26
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-1.023	-1150857.250	-8.39
SOIL WATER AT START OF YEAR	345.960	389308224.000	
SOIL WATER AT END OF YEAR	345.094	388334496.000	
SNOW WATER AT START OF YEAR	0.157	177140.328	1.29

AVG. HEAD ON TOP OF LAYER 3	0.0127		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.513	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.218	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.652	-733910.687	-3.54
SOIL WATER AT START OF YEAR	345.614	388919936.000	
SOIL WATER AT END OF YEAR	344.962	388186016.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-7.396	0.00

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ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.11	14752683.000	100.00
RUNOFF	0.194	218700.484	1.48
EVAPOTRANSPIRATION	12.058	13568477.000	91.97
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.858	965484.625	6.54
SOIL WATER AT START OF YEAR	344.962	388186016.000	
SOIL WATER AT END OF YEAR	345.309	388576320.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.511	575194.250	3.90
ANNUAL WATER BUDGET BALANCE	0.0000	20.088	0.00

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ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.38	15056514.000	100.00
RUNOFF	0.571	642497.250	4.27
EVAPOTRANSPIRATION	13.484	15173860.000	100.78
DRAINAGE COLLECTED FROM LAYER 2	0.1916	215563.609	1.43
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.223	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0018		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.128	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.094	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.867	-975391.375	-6.48
SOIL WATER AT START OF YEAR	345.309	388576320.000	
SOIL WATER AT END OF YEAR	344.935	388155072.000	
SNOW WATER AT START OF YEAR	0.511	575194.250	3.82
SNOW WATER AT END OF YEAR	0.019	21034.896	0.14
ANNUAL WATER BUDGET BALANCE	0.0000	-15.446	0.00

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AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.374	-420751.219	-3.57
SOIL WATER AT START OF YEAR	346.386	389787872.000	
SOIL WATER AT END OF YEAR	346.012	389367136.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.264	0.00

ANNUAL TOTALS FOR YEAR 49

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.26	16046780.000	100.00
RUNOFF	0.137	153941.937	0.96
EVAPOTRANSPIRATION	13.529	15223849.000	94.87
DRAINAGE COLLECTED FROM LAYER 2	0.4346	489065.531	3.05
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.342	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0043		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.198	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.144	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.160	179914.750	1.12
SOIL WATER AT START OF YEAR	346.012	389367136.000	
SOIL WATER AT END OF YEAR	346.172	389547040.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	8.646	0.00

ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.01	14640158.000	100.00
RUNOFF	0.044	49760.160	0.34
EVAPOTRANSPIRATION	14.147	15919980.000	108.74
DRAINAGE COLLECTED FROM LAYER 2	0.0564	63435.301	0.43
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.188	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.106	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.082	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-1.238	-1393025.750	-9.52
SOIL WATER AT START OF YEAR	346.172	389547040.000	
SOIL WATER AT END OF YEAR	344.934	388154016.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	7.660	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00000 (0.00000)	0.066	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.043	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000 (0.000)		
CHANGE IN WATER STORAGE	-0.017 (0.8704)	-19688.08	-0.140

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	1.36	1530408.000
RUNOFF	0.269	302437.4690
DRAINAGE COLLECTED FROM LAYER 2	0.26796	301537.93700
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.12190
AVERAGE HEAD ON TOP OF LAYER 3	0.955	
MAXIMUM HEAD ON TOP OF LAYER 3	1.754	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	20.4 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.00000	0.10497
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00766
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.011	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.12	2388627.7500
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3014	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1346	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	3.3192	0.1383
2	0.0321	0.1285
3	0.0000	0.0000
4	0.4500	0.7500
5	3.4080	0.2840
6	332.8800	0.2920
7	4.3920	0.2440
8	0.0025	0.0100
9	0.0000	0.0000
10	0.4500	0.7500
SNOW WATER	0.000	

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LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.60 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	75.00	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	310.000	ACRES
EVAPORATIVE ZONE DEPTH	=	32.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.693	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	19.834	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.818	INCHES
INITIAL SNOW WATER	=	0.131	INCHES
INITIAL WATER IN LAYER MATERIALS	=	88.545	INCHES
TOTAL INITIAL WATER	=	88.676	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SALT LAKE CITY UTAH

STATION LATITUDE	=	40.76 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	117
END OF GROWING SEASON (JULIAN DATE)	=	289
EVAPORATIVE ZONE DEPTH	=	32.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	48.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	39.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.11	1.10	1.41	1.81	1.21	0.80
0.59	0.75	0.73	0.93	1.00	1.12

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	34.10	40.70	49.20	58.80	68.30
77.50	74.90	65.00	53.00	39.70	30.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH
AND STATION LATITUDE = 40.76 DEGREES

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.81	14415096.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	13.118	14761962.000	102.41
DRAINAGE COLLECTED FROM LAYER 4	0.0001	113.901	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.022	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.308	-346983.937	-2.41
SOIL WATER AT START OF YEAR	88.560	99656944.000	
SOIL WATER AT END OF YEAR	88.383	99457736.000	
SNOW WATER AT START OF YEAR	0.131	147777.891	1.03
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.320	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.23 0.38	0.70 0.93	1.41 0.14	0.85 0.44	0.34 0.18	1.73 1.14
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.204 0.337	1.012 0.616	1.564 0.499	0.927 0.162	0.519 0.423	1.743 0.373
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0002	0.0000 0.0000	0.0000 0.0000	0.0001 0.0000	0.0007 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.47	9531293.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.380	9429975.000	98.94
DRAINAGE COLLECTED FROM LAYER 4	0.0010	1164.322	0.01
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.118	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.089	100145.578	1.05

	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.444 0.746	0.421 0.053	1.752 0.930	2.019 0.322	2.360 0.513	1.068 0.429
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.46	11770640.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.056	12440954.000	105.69
DRAINAGE COLLECTED FROM LAYER 4	0.0001	66.001	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.031	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.596	-670384.187	-5.70
SOIL WATER AT START OF YEAR	88.707	99821528.000	
SOIL WATER AT END OF YEAR	88.116	99157440.000	
SNOW WATER AT START OF YEAR	0.006	6298.169	0.05
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	4.533	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 6

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.54 0.73	0.95 1.13	1.90 0.84	1.93 1.08	0.87 0.91	1.14 1.67
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.658 1.012	0.601 0.823	1.659 1.274	2.557 0.799	0.945 0.452	1.946 0.822
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0003	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 6

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MONTHLY TOTALS (IN INCHES) FOR YEAR 8

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.29	1.77	0.55	2.71	1.07	0.29
	0.33	0.17	0.12	0.68	1.07	0.92
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.269	0.928	1.341	2.080	2.279	0.867
	0.318	0.183	0.125	0.310	0.470	0.617
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.97	11219242.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.737	11012985.000	98.16
DRAINAGE COLLECTED FROM LAYER 4	0.0016	1789.600	0.02
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.079	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.182	204463.437	1.82
SOIL WATER AT START OF YEAR	88.343	99412800.000	
SOIL WATER AT END OF YEAR	88.870	100005048.000	
SNOW WATER AT START OF YEAR	0.437	492126.437	4.39
SNOW WATER AT END OF YEAR	0.093	104346.172	0.93
ANNUAL WATER BUDGET BALANCE	0.0000	4.729	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.28	1.72	1.40	3.31	0.08	0.83
	0.73	2.21	0.12	0.90	0.79	0.70
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.698	0.526	1.121	2.273	1.319	1.333
	2.895	2.377	0.106	0.672	0.420	0.368
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0004	0.0172
	0.0178	0.0601	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

CHANGE IN WATER STORAGE	0.115	129717.594	1.00
SOIL WATER AT START OF YEAR	88.628	99732872.000	
SOIL WATER AT END OF YEAR	88.577	99675272.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.166	187316.766	1.44
ANNUAL WATER BUDGET BALANCE	0.0000	1.414	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 11

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.94 1.47	0.54 0.30	3.09 0.71	2.19 0.30	0.98 1.19	0.68 1.19
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.473 2.537	0.547 0.352	1.648 0.726	2.289 0.259	2.018 0.320	1.381 0.617
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0004	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.58	15281576.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	13.166	14815846.000	96.95
DRAINAGE COLLECTED FROM LAYER 4	0.0005	535.047	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.032	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.413	465196.187	3.04
SOIL WATER AT START OF YEAR	88.577	99675272.000	
SOIL WATER AT END OF YEAR	89.156	100327784.000	
SNOW WATER AT START OF YEAR	0.166	187316.766	1.23
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.352	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 12

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.26 0.17	1.10 0.22	1.32 0.15	0.79 1.54	2.31 0.58	0.63 0.68

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.08	12468327.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.736	12080743.000	96.89
DRAINAGE COLLECTED FROM LAYER 4	0.0000	37.214	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.013	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.344	387541.187	3.11
SOIL WATER AT START OF YEAR	89.166	100338448.000	
SOIL WATER AT END OF YEAR	89.579	100803808.000	
SNOW WATER AT START OF YEAR	0.104	116499.359	0.93
SNOW WATER AT END OF YEAR	0.034	38679.840	0.31
ANNUAL WATER BUDGET BALANCE	0.0000	5.394	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 14

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.23	0.69	1.99	1.61	1.09	0.31
	0.40	0.13	0.46	1.48	0.73	1.35
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.757	0.505	1.416	1.969	2.203	1.361
	0.958	0.161	0.244	0.495	0.423	0.625
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.47	12907193.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.115	12507877.000	96.91
DRAINAGE COLLECTED FROM LAYER 4	0.0009	1064.218	0.01
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.023	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.354	398243.281	3.09
SOIL WATER AT START OF YEAR	89.579	100803808.000	
SOIL WATER AT END OF YEAR	89.590	100816032.000	
SNOW WATER AT START OF YEAR	0.034	38679.840	0.30
SNOW WATER AT END OF YEAR	0.377	424697.594	3.29
ANNUAL WATER BUDGET BALANCE	0.0000	9.252	0.00

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.83	13312302.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.716	14309044.000	107.49
DRAINAGE COLLECTED FROM LAYER 4	0.0117	13150.743	0.10
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.054	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.897	-1009895.620	-7.59
SOIL WATER AT START OF YEAR	89.945	101215216.000	
SOIL WATER AT END OF YEAR	89.048	100205328.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.044	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 17

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.13 0.04	1.58 1.40	1.55 0.59	1.13 0.08	1.55 1.91	0.27 1.26
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.114 0.520	0.593 1.248	1.279 0.482	1.946 0.311	1.867 0.462	1.299 0.354
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0101	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.49	12929699.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.475	11787676.000	91.17
DRAINAGE COLLECTED FROM LAYER 4	0.0101	11376.008	0.09
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.037	0.00

					OPEN.OUT	
PRECIPITATION	1.17 0.28	1.02 0.36	0.97 0.21	0.93 0.53	0.45 0.39	0.06 1.02
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.573 0.566	0.494 0.360	1.072 0.129	2.200 0.396	0.957 0.241	0.954 0.278
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.44	8372232.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.221	9250969.000	110.50
DRAINAGE COLLECTED FROM LAYER 4	0.0000	35.318	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.009	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.781	-878764.625	-10.50
SOIL WATER AT START OF YEAR	89.607	100834816.000	
SOIL WATER AT END OF YEAR	88.607	99709184.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.219	246870.203	2.95
ANNUAL WATER BUDGET BALANCE	0.0000	-7.274	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.80 0.78	0.53 0.47	1.96 1.06	2.05 0.24	1.22 1.23	1.60 3.00
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.501 0.777	0.448 0.481	0.733 0.966	2.310 0.269	2.723 0.572	2.475 0.416
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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MONTHLY TOTALS (IN INCHES) FOR YEAR 22

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.50 0.34	1.51 0.79	1.81 0.69	1.80 1.41	0.03 1.73	0.74 1.83
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.421 0.680	0.633 0.804	1.590 0.292	2.560 1.062	0.827 0.708	1.009 0.650
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0019 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	14831456.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.236	12643668.000	85.25
DRAINAGE COLLECTED FROM LAYER 4	0.0020	2249.114	0.02
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.053	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	1.942	2185538.500	14.74
SOIL WATER AT START OF YEAR	88.563	99659768.000	
SOIL WATER AT END OF YEAR	89.717	100958584.000	
SNOW WATER AT START OF YEAR	0.114	127844.250	0.86
SNOW WATER AT END OF YEAR	0.902	1014564.120	6.84
ANNUAL WATER BUDGET BALANCE	0.0000	0.759	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 23

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.96 0.91	1.62 0.92	1.45 0.98	2.88 2.58	0.78 1.74	0.04 0.96
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.688 2.832	0.734 1.647	1.745 0.760	2.814 1.616	1.519 0.959	1.162 0.590
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0078	0.0000 0.0058	0.0310 0.0000	0.1254 0.0001	0.1126 0.0000	0.0847 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.305	-342925.094	-2.41
SOIL WATER AT START OF YEAR	89.949	101219144.000	
SOIL WATER AT END OF YEAR	89.504	100719184.000	
SNOW WATER AT START OF YEAR	0.057	64298.805	0.45
SNOW WATER AT END OF YEAR	0.197	221333.406	1.55
ANNUAL WATER BUDGET BALANCE	0.0000	5.520	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.71 0.88	1.08 0.42	1.85 0.98	0.87 0.42	1.80 1.13	0.74 1.05
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.464 2.759	0.389 0.420	1.770 0.980	1.920 0.268	1.463 0.719	1.194 0.616
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0001	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0001 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.93	13424831.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.962	14586501.000	108.65
DRAINAGE COLLECTED FROM LAYER 4	0.0004	426.718	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.039	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-1.033	-1162099.250	-8.66
SOIL WATER AT START OF YEAR	89.504	100719184.000	
SOIL WATER AT END OF YEAR	88.530	99622528.000	
SNOW WATER AT START OF YEAR	0.197	221333.406	1.65
SNOW WATER AT END OF YEAR	0.139	155893.359	1.16
ANNUAL WATER BUDGET BALANCE	0.0000	2.813	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 26

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	14831455.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	13.664	15375564.000	103.67
DRAINAGE COLLECTED FROM LAYER 4	0.0177	19902.418	0.13
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.038	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.501	-564017.062	-3.80
SOIL WATER AT START OF YEAR	90.070	101355664.000	
SOIL WATER AT END OF YEAR	89.201	100377512.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.368	414138.437	2.79
ANNUAL WATER BUDGET BALANCE	0.0000	5.814	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.98	0.87	1.44	1.00	1.06	0.89
	0.59	0.29	0.38	2.53	2.82	0.80
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.681	0.698	0.547	1.884	1.558	1.349
	1.971	0.284	0.347	0.846	0.585	0.390
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.65	15360351.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.138	12533339.000	81.60
DRAINAGE COLLECTED FROM LAYER 4	0.0004	445.234	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.041	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	2.512	2826567.000	18.40
SOIL WATER AT START OF YEAR	89.201	100377512.000	
SOIL WATER AT END OF YEAR	91.798	103300136.000	
SNOW WATER AT START OF YEAR	0.368	414138.437	2.70
SNOW WATER AT END OF YEAR	0.283	318077.312	2.07

					OPEN.OUT	
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.22	11500567.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.110	11377053.000	98.93
DRAINAGE COLLECTED FROM LAYER 4	0.0004	401.279	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.071	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.109	123114.031	1.07
SOIL WATER AT START OF YEAR	88.279	99340232.000	
SOIL WATER AT END OF YEAR	88.388	99463344.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.058	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 31

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.17 0.72	2.03 1.84	0.98 0.44	2.16 0.52	1.69 1.08	1.54 0.40
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.475 1.154	0.560 1.827	1.727 0.438	2.979 0.511	1.470 0.634	2.632 0.371
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0001	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0001 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.57	16395626.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	14.789	16642355.000	101.50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.21 0.04	0.37 0.10	1.41 0.68	1.94 2.04	1.81 0.75	1.42 0.84
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.191 0.062	0.519 0.102	1.306 0.418	2.186 0.877	2.152 0.532	1.767 0.648
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0003 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.61	13064737.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.759	12107392.000	92.67
DRAINAGE COLLECTED FROM LAYER 4	0.0004	406.802	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.052	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.850	956932.687	7.32
SOIL WATER AT START OF YEAR	88.655	99763968.000	
SOIL WATER AT END OF YEAR	89.401	100602416.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.105	118436.633	0.91
ANNUAL WATER BUDGET BALANCE	0.0000	5.135	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 34

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.48 0.80	0.35 1.35	1.11 0.03	1.49 1.44	1.63 0.72	0.04 1.31
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.316 0.808	0.479 0.880	1.381 0.500	1.937 0.524	1.197 0.397	1.618 0.539
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-5.855	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 36

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.17	1.27	0.52	0.71	1.65	0.96
	0.28	0.31	0.33	0.42	0.48	2.13
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.464	0.503	1.313	1.399	1.575	1.724
	1.002	0.189	0.351	0.519	0.227	0.558
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

ANNUAL TOTALS FOR YEAR 36

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.23	11511821.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.822	11052317.000	96.01
DRAINAGE COLLECTED FROM LAYER 4	0.0001	65.399	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.069	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.408	459436.844	3.99
SOIL WATER AT START OF YEAR	89.089	100252320.000	
SOIL WATER AT END OF YEAR	89.498	100711760.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.068	0.00

MONTHLY TOTALS (IN INCHES) FOR YEAR 37

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.15	1.63	1.08	0.62	2.12	0.47
	0.99	0.18	0.69	1.23	1.47	0.72
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.570	0.771	1.047	1.890	2.367	1.385
	1.850	0.180	0.646	0.668	0.511	0.326
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001

EVAPOTRANSPIRATION	10.767	12116324.000	106.82
DRAINAGE COLLECTED FROM LAYER 4	0.0001	66.610	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.030	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.687	-773366.187	-6.82
SOIL WATER AT START OF YEAR	89.629	100859488.000	
SOIL WATER AT END OF YEAR	88.846	99978760.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.095	107362.695	0.95
ANNUAL WATER BUDGET BALANCE	0.0000	-0.757	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 39

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.31	1.07	1.25	1.47	0.75	1.37
	0.23	1.56	0.25	1.78	1.29	1.56
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.544	0.595	1.295	1.778	2.018	1.899
	1.592	1.560	0.176	0.749	0.731	0.794
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.89	16755717.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	13.731	15451326.000	92.22
DRAINAGE COLLECTED FROM LAYER 4	0.0001	124.461	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.034	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	1.159	1304266.250	7.78
SOIL WATER AT START OF YEAR	88.846	99978760.000	
SOIL WATER AT END OF YEAR	89.943	101213248.000	
SNOW WATER AT START OF YEAR	0.095	107362.695	0.64
SNOW WATER AT END OF YEAR	0.157	177140.328	1.06
ANNUAL WATER BUDGET BALANCE	0.0000	0.931	0.00

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STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 41

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.43	18488686.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	14.587	16414432.000	88.78
DRAINAGE COLLECTED FROM LAYER 4	0.0205	23063.771	0.12
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.155	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	1.823	2051181.750	11.09
SOIL WATER AT START OF YEAR	88.322	99389160.000	
SOIL WATER AT END OF YEAR	89.824	101078496.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.322	361840.969	1.96
ANNUAL WATER BUDGET BALANCE	0.0000	7.815	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 42

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.25 0.40	1.18 0.02	0.60 0.13	3.11 0.55	2.17 0.54	0.64 1.27
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.330 1.247	0.515 0.020	1.249 0.130	2.685 0.327	2.411 0.289	2.388 0.522
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 42

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.86	12220761.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.112	13629909.000	111.53
DRAINAGE COLLECTED FROM LAYER 4	0.0000	3.467	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.034	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-1.252	-1409151.500	-11.53
SOIL WATER AT START OF YEAR	89.824	101078496.000	
SOIL WATER AT END OF YEAR	88.893	100031184.000	

LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.11	14752683.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.545	14116406.000	95.69
DRAINAGE COLLECTED FROM LAYER 4	0.0000	16.387	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.027	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	0.565	636261.937	4.31
SOIL WATER AT START OF YEAR	88.617	99720944.000	
SOIL WATER AT END OF YEAR	88.671	99782016.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.511	575194.250	3.90
ANNUAL WATER BUDGET BALANCE	0.0000	-1.389	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 45

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.71 0.04	2.27 0.66	1.31 2.52	0.86 0.09	2.24 0.64	0.37 0.57
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.800 1.530	0.694 0.649	1.526 1.700	2.145 0.892	2.302 0.377	1.302 0.548
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0132	0.0000 0.0000	0.0000 0.0002	0.0000 0.0000	0.0000 0.0000	0.0001 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.38	15056514.000	100.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 47

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.75 0.39	0.92 0.30	2.96 1.24	0.69 1.45	1.12 1.40	0.27 1.29
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.224 2.799	0.491 0.300	1.227 0.620	2.339 1.426	1.070 0.720	1.186 0.411
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0054 0.0000	0.0124 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 47

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.78	14381337.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.815	14420642.000	100.27
DRAINAGE COLLECTED FROM LAYER 4	0.0179	20111.148	0.14
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.212	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-0.053	-59419.262	-0.41
SOIL WATER AT START OF YEAR	89.926	101193616.000	
SOIL WATER AT END OF YEAR	89.873	101134200.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.060	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 48

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.38 0.00	0.96 1.82	0.56 0.02	1.30 1.27	0.16 1.10	0.46 1.44
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.491 1.012	0.520 1.820	1.688 0.020	1.574 0.210	0.644 0.635	1.094 0.699
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000

SOIL WATER AT END OF YEAR	89.270	100455064.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-9.200	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.51 0.35	0.77 0.66	2.66 0.65	0.52 0.52	2.27 0.49	1.98 0.63
RUNOFF	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION	0.632 1.979	0.651 0.611	1.963 0.579	1.820 0.592	2.096 0.392	2.518 0.484
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.01	14640158.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	14.316	16109291.000	110.03
DRAINAGE COLLECTED FROM LAYER 4	0.0001	83.935	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.053	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	-1.306	-1469220.870	-10.04
SOIL WATER AT START OF YEAR	89.270	100455064.000	
SOIL WATER AT END OF YEAR	87.964	98985840.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.939	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.02 0.52	1.11 0.72	1.53 0.71	1.63 0.89	1.27 0.99	0.89 1.19
STD. DEVIATIONS	0.57 0.37	0.52 0.62	0.69 0.59	0.77 0.62	0.64 0.54	0.58 0.47

```
*** Maximum heads are computed using McEnroe's equations. ***

    Reference: Maximum Saturated Depth over Landfill Liner
               by Bruce M. McEnroe, University of Kansas
               ASCE Journal of Environmental Engineering
               Vol. 119, No. 2, March 1993, pp. 262-270.
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0
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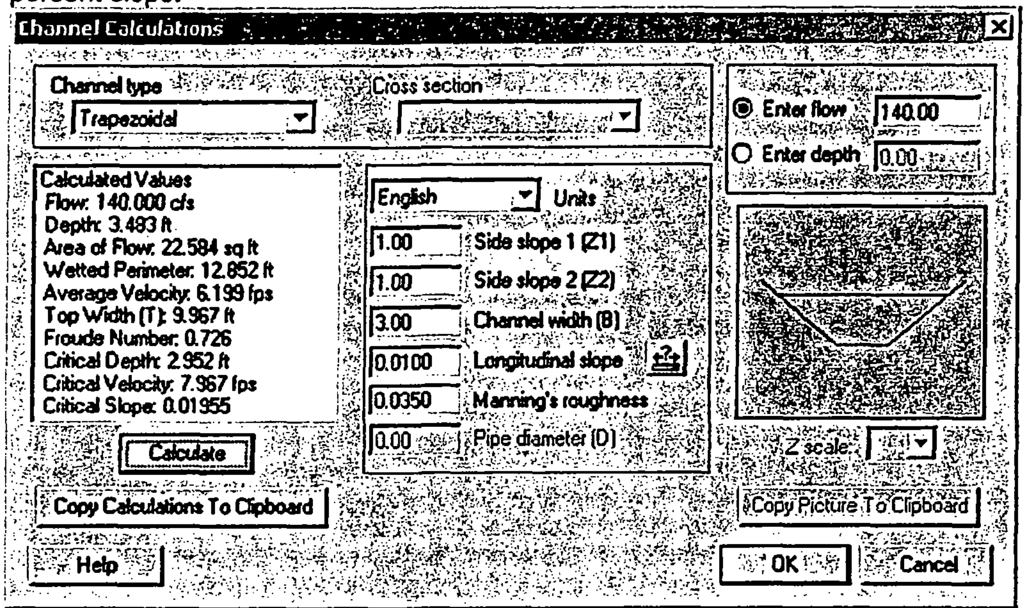
FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.0718	0.1786
2	82.0477	0.2735
3	4.3920	0.2440
4	0.0025	0.0100
5	0.0000	0.0000
6	0.4500	0.7500
SNOW WATER	0.000	

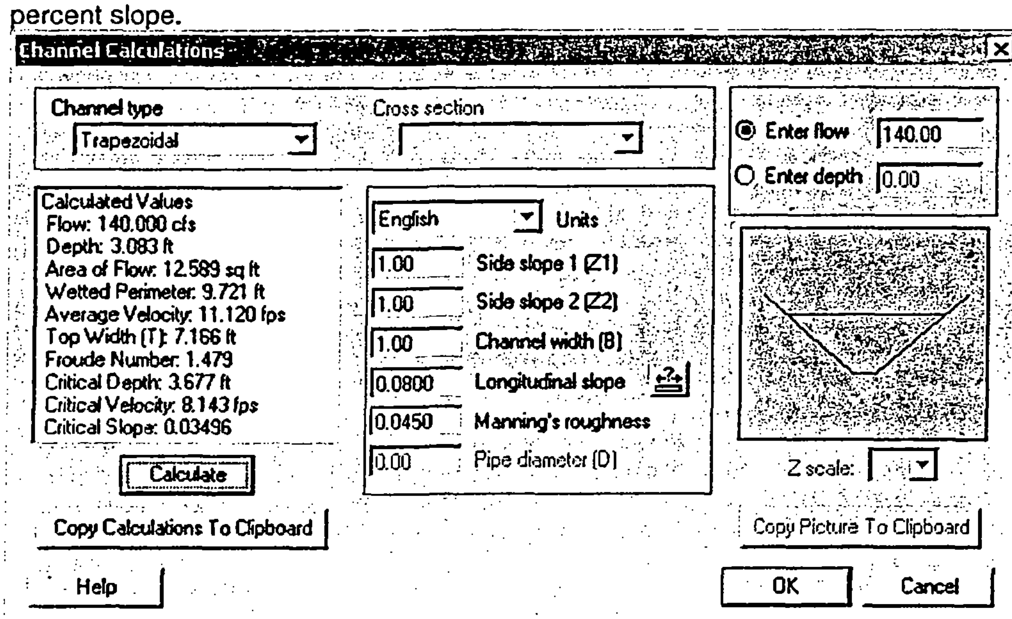
****
****

APPENDIX 4.9
Hydraulic Calculations

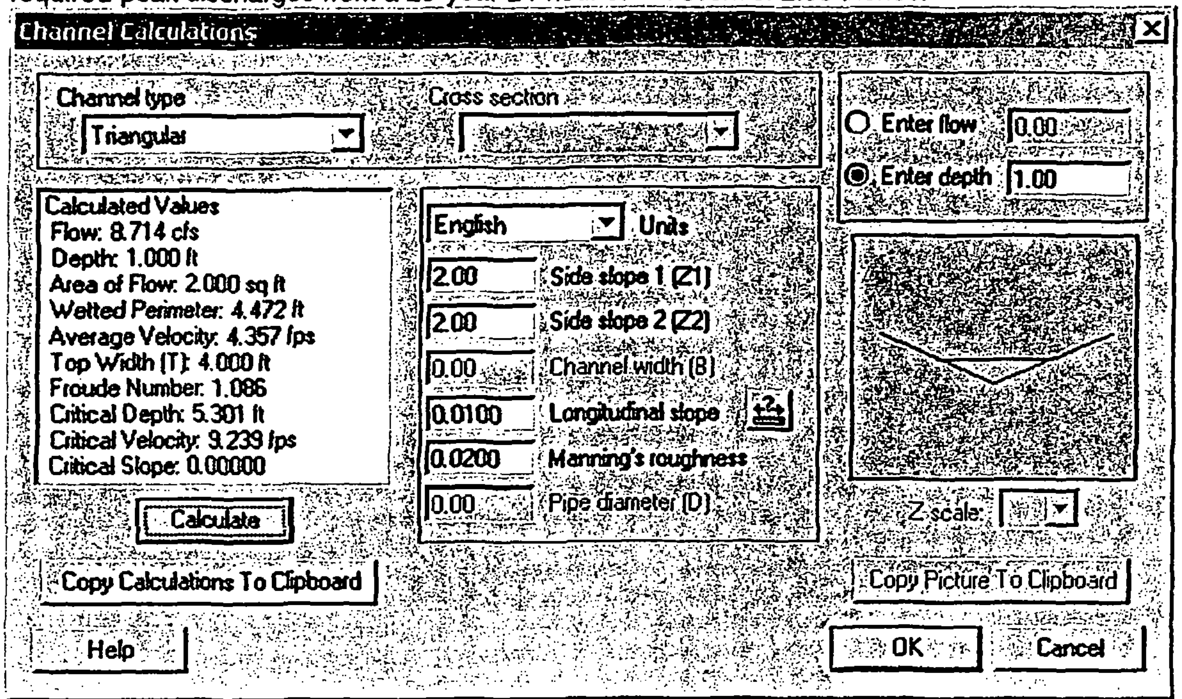
Trapezoidal cross-section, with geometry and depth described below, to convey 140 cfs at 1 percent slope.



Trapezoidal cross-section, with geometry and depth described below, to convey 140 cfs at 8 percent slope.



Triangular cross-section for cut-ditch on finished-grade terraces. Hydraulic capacity exceeds the required peak discharges from a 25-year 24-hour storm event of 2.08 inches.



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1***************************************
**************************************
 *                                      *                                                                            *
*
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                                            *
U.S. ARMY CORPS OF ENGINEERS     *
 *                  MAY    1991         *                                                                            *
HYDROLOGIC ENGINEERING CENTER    *
 *              VERSION 4.0.1E          *                                                                            *
609 SECOND STREET            *
 *                                      *                                                                            *
DAVIS, CALIFORNIA 95616       *
 *  RUN DATE  00000000  TIME  00000000  *                                                                            *
(916) 551-1748            *
 *                                      *                                                                            *
*
 ***************************************
**************************************


                                                              X      X  XXXXXXX   XXXXX           X
                                                              X      X  X        X     X         XX
                                                              X      X  X        X                X
                                                              XXXXXXX  XXXX      X        XXXXX   X
                                                              X      X  X        X                X
                                                              X      X  X        X     X          X
                                                              X      X  XXXXXXX   XXXXX          XXX


            THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS,
HEC1DB, AND HEC1KW.

            THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE
1973-STYLE INPUT STRUCTURE.
            THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS
THE FORTRAN77 VERSION
            NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE
STAGE FREQUENCY,
            DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT
INFILTRATION
            KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


                                                                  HEC-1 INPUT
PAGE  1

           LINE
ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

             1            ID  HEC-1 Analysis using WMS
             2            ID
             3            ID
                          *DIAGRAM
             4            IT       5  1JAN94       0      500
             5            IO       0

             6            KK   SOUTH
             7            KO       0        0     0.0       0       22
             8            BA     0.4
             9            PB    2.08
            10            IN       6  1JAN94       0
                          * typeII-24hour
            11            PC     0.0    0.001    0.002  0.0031  0.0041  0.0051  0.0062  0.0073  0.0083
0.0094
            12            PC  0.0105   0.0116   0.0127  0.0138   0.015  0.0161  0.0173  0.0185  0.0196
0.0208
```

```
               LINE
ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                50             PC     0.048  0.0494  0.0508  0.0523  0.0538  0.0553  0.0568  0.0583  0.0598
0.0614
                51             PC     0.063  0.0646  0.0662  0.0679  0.0696  0.0712   0.073  0.0747  0.0764
0.0782
                52             PC      0.08  0.0818  0.0836  0.0855  0.0874  0.0892  0.0912  0.0931   0.095
0.097
                53             PC     0.099   0.101   0.103  0.1051  0.1072  0.1093  0.1114  0.1135  0.1156
0.1178
                54             PC      0.12  0.1223  0.1246  0.1271  0.1296  0.1323   0.135  0.1379  0.1408
0.1439
                55             PC     0.147  0.1502  0.1534  0.1566  0.1598   0.163  0.1663  0.1697  0.1733
0.1771
                56             PC     0.181  0.1851  0.1895  0.1941  0.1989   0.204  0.2094  0.2152  0.2214
0.228
                57             PC     0.235  0.2427  0.2513  0.2609  0.2715   0.283  0.3068  0.3544  0.4308
0.5679
                58             PC     0.663   0.682  0.6986   0.713  0.7252   0.735  0.7434  0.7514  0.7588
0.7656
                59             PC     0.772   0.778  0.7836   0.789  0.7942   0.799  0.8036   0.808  0.8122
0.8162
                60             PC      0.82  0.8237  0.8273  0.8308  0.8342  0.8376  0.8409  0.8442  0.8474
0.8505
                61             PC    0.8535  0.8565  0.8594  0.8622  0.8649  0.8676  0.8702  0.8728  0.8753
0.8777
                62             PC      0.88  0.8823  0.8845  0.8868   0.889  0.8912  0.8933  0.8955  0.8976
0.8997
                63             PC    0.9018  0.9038  0.9058  0.9078  0.9097  0.9117  0.9136  0.9155  0.9174
0.9192
                64             PC     0.921  0.9228  0.9245  0.9263   0.928  0.9297  0.9314   0.933  0.9346
0.9362
                65             PC    0.9377  0.9393  0.9408  0.9423  0.9437  0.9452  0.9466   0.948  0.9494
0.9507
                66             PC     0.952  0.9533  0.9546  0.9559  0.9572  0.9584  0.9597   0.961  0.9622
0.9635
                67             PC    0.9648   0.966  0.9672  0.9685  0.9697  0.9709  0.9722  0.9734  0.9746
0.9758
                68             PC     0.977  0.9782  0.9794  0.9806  0.9818  0.9829  0.9841  0.9853  0.9864
0.9876
                69             PC    0.9888  0.9899   0.991  0.9922  0.9933  0.9944  0.9956  0.9967  0.9978
0.9989
                70             PC       1.0
                71             LS       0.0    75.0     0.0
                72             UD       1.0

                73             KK        1R   CNAME      1C
                74             KO         0       0     0.0       0      22
                75             RN        1R
                76             ZZ
```

```
*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
*** *** *** *** *** *** *** ***

                 **************
                 *            *
      6 KK       *    SOUTH   *
                 *            *
                 **************

      7 KO            OUTPUT CONTROL VARIABLES
                            IPRNT          0  PRINT CONTROL
                            IPLOT          0  PLOT CONTROL
                            QSCAL         0.  HYDROGRAPH PLOT SCALE
                            IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                             IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                            ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                            ISAV2        500  LAST ORDINATE PUNCHED OR SAVED
                           TIMINT      0.083  TIME INTERVAL IN HOURS


     10 IN            TIME DATA FOR INPUT TIME SERIES
                            JXMIN          6  TIME INTERVAL IN MINUTES
                           JXDATE    1JAN94  STARTING DATE
                           JXTIME          0  STARTING TIME

                    SUBBASIN RUNOFF DATA

      8 BA            SUBBASIN CHARACTERISTICS
                            TAREA,      0.40  SUBBASIN AREA

                      PRECIPITATION DATA

      9 PB                  STORM       2.08  BASIN TOTAL PRECIPITATION

     11 PI              INCREMENTAL PRECIPITATION PATTERN
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.00      0.00
                          0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   0.01      0.01
                          0.01     0.01     0.01     0.01     0.01     0.01     0.01     0.01
   0.02      0.04
                          0.05     0.08     0.11     0.08     0.02     0.01     0.01     0.01
   0.01      0.01
                          0.01     0.01     0.01     0.01     0.01     0.01     0.00     0.00
   0.00      0.00
```

	1 JAN 0010	3	0.00	0.00	0.00	0.	*	1 JAN 2100	253	0.00
0.00	0.00	4.								
	1 JAN 0015	4	0.00	0.00	0.00	0.	*	1 JAN 2105	254	0.00
0.00	0.00	4.								
	1 JAN 0020	5	0.00	0.00	0.00	0.	*	1 JAN 2110	255	0.00
0.00	0.00	4.								
	1 JAN 0025	6	0.00	0.00	0.00	0.	*	1 JAN 2115	256	0.00
0.00	0.00	4.								
	1 JAN 0030	7	0.00	0.00	0.00	0.	*	1 JAN 2120	257	0.00
0.00	0.00	4.								
	1 JAN 0035	8	0.00	0.00	0.00	0.	*	1 JAN 2125	258	0.00
0.00	0.00	3.								
	1 JAN 0040	9	0.00	0.00	0.00	0.	*	1 JAN 2130	259	0.00
0.00	0.00	3.								
	1 JAN 0045	10	0.00	0.00	0.00	0.	*	1 JAN 2135	260	0.00
0.00	0.00	3.								
	1 JAN 0050	11	0.00	0.00	0.00	0.	*	1 JAN 2140	261	0.00
0.00	0.00	3.								
	1 JAN 0055	12	0.00	0.00	0.00	0.	*	1 JAN 2145	262	0.00
0.00	0.00	3.								
	1 JAN 0100	13	0.00	0.00	0.00	0.	*	1 JAN 2150	263	0.00
0.00	0.00	3.								
	1 JAN 0105	14	0.00	0.00	0.00	0.	*	1 JAN 2155	264	0.00
0.00	0.00	3.								
	1 JAN 0110	15	0.00	0.00	0.00	0.	*	1 JAN 2200	265	0.00
0.00	0.00	3.								
	1 JAN 0115	16	0.00	0.00	0.00	0.	*	1 JAN 2205	266	0.00
0.00	0.00	3.								
	1 JAN 0120	17	0.00	0.00	0.00	0.	*	1 JAN 2210	267	0.00
0.00	0.00	3.								
	1 JAN 0125	18	0.00	0.00	0.00	0.	*	1 JAN 2215	268	0.00
0.00	0.00	3.								
	1 JAN 0130	19	0.00	0.00	0.00	0.	*	1 JAN 2220	269	0.00
0.00	0.00	3.								
	1 JAN 0135	20	0.00	0.00	0.00	0.	*	1 JAN 2225	270	0.00
0.00	0.00	3.								
	1 JAN 0140	21	0.00	0.00	0.00	0.	*	1 JAN 2230	271	0.00
0.00	0.00	3.								
	1 JAN 0145	22	0.00	0.00	0.00	0.	*	1 JAN 2235	272	0.00
0.00	0.00	3.								
	1 JAN 0150	23	0.00	0.00	0.00	0.	*	1 JAN 2240	273	0.00
0.00	0.00	3.								
	1 JAN 0155	24	0.00	0.00	0.00	0.	*	1 JAN 2245	274	0.00
0.00	0.00	3.								
	1 JAN 0200	25	0.00	0.00	0.00	0.	*	1 JAN 2250	275	0.00
0.00	0.00	3.								
	1 JAN 0205	26	0.00	0.00	0.00	0.	*	1 JAN 2255	276	0.00
0.00	0.00	3.								
	1 JAN 0210	27	0.00	0.00	0.00	0.	*	1 JAN 2300	277	0.00
0.00	0.00	3.								
	1 JAN 0215	28	0.00	0.00	0.00	0.	*	1 JAN 2305	278	0.00
0.00	0.00	3.								
	1 JAN 0220	29	0.00	0.00	0.00	0.	*	1 JAN 2310	279	0.00
0.00	0.00	3.								
	1 JAN 0225	30	0.00	0.00	0.00	0.	*	1 JAN 2315	280	0.00
0.00	0.00	3.								
	1 JAN 0230	31	0.00	0.00	0.00	0.	*	1 JAN 2320	281	0.00
0.00	0.00	3.								
	1 JAN 0235	32	0.00	0.00	0.00	0.	*	1 JAN 2325	282	0.00
0.00	0.00	3.								
	1 JAN 0240	33	0.00	0.00	0.00	0.	*	1 JAN 2330	283	0.00
0.00	0.00	3.								
	1 JAN 0245	34	0.00	0.00	0.00	0.	*	1 JAN 2335	284	0.00
0.00	0.00	3.								
	1 JAN 0250	35	0.00	0.00	0.00	0.	*	1 JAN 2340	285	0.00
0.00	0.00	3.								
	1 JAN 0255	36	0.00	0.00	0.00	0.	*	1 JAN 2345	286	0.00
0.00	0.00	3.								
	1 JAN 0300	37	0.00	0.00	0.00	0.	*	1 JAN 2350	287	0.00
0.00	0.00	3.								

1 JAN 0600	73	0.00	0.00	0.00	0.	*	2 JAN 0250	323	0.00	0.00	0.00	0.
1 JAN 0605	74	0.00	0.00	0.00	0.	*	2 JAN 0255	324	0.00	0.00	0.00	0.
1 JAN 0610	75	0.00	0.00	0.00	0.	*	2 JAN 0300	325	0.00	0.00	0.00	0.
1 JAN 0615	76	0.00	0.00	0.00	0.	*	2 JAN 0305	326	0.00	0.00	0.00	0.
1 JAN 0620	77	0.00	0.00	0.00	0.	*	2 JAN 0310	327	0.00	0.00	0.00	0.
1 JAN 0625	78	0.00	0.00	0.00	0.	*	2 JAN 0315	328	0.00	0.00	0.00	0.
1 JAN 0630	79	0.00	0.00	0.00	0.	*	2 JAN 0320	329	0.00	0.00	0.00	0.
1 JAN 0635	80	0.00	0.00	0.00	0.	*	2 JAN 0325	330	0.00	0.00	0.00	0.
1 JAN 0640	81	0.00	0.00	0.00	0.	*	2 JAN 0330	331	0.00	0.00	0.00	0.
1 JAN 0645	82	0.00	0.00	0.00	0.	*	2 JAN 0335	332	0.00	0.00	0.00	0.
1 JAN 0650	83	0.00	0.00	0.00	0.	*	2 JAN 0340	333	0.00	0.00	0.00	0.
1 JAN 0655	84	0.00	0.00	0.00	0.	*	2 JAN 0345	334	0.00	0.00	0.00	0.
1 JAN 0700	85	0.00	0.00	0.00	0.	*	2 JAN 0350	335	0.00	0.00	0.00	0.
1 JAN 0705	86	0.00	0.00	0.00	0.	*	2 JAN 0355	336	0.00	0.00	0.00	0.
1 JAN 0710	87	0.00	0.00	0.00	0.	*	2 JAN 0400	337	0.00	0.00	0.00	0.
1 JAN 0715	88	0.00	0.00	0.00	0.	*	2 JAN 0405	338	0.00	0.00	0.00	0.
1 JAN 0720	89	0.00	0.00	0.00	0.	*	2 JAN 0410	339	0.00	0.00	0.00	0.
1 JAN 0725	90	0.00	0.00	0.00	0.	*	2 JAN 0415	340	0.00	0.00	0.00	0.
1 JAN 0730	91	0.00	0.00	0.00	0.	*	2 JAN 0420	341	0.00	0.00	0.00	0.
1 JAN 0735	92	0.00	0.00	0.00	0.	*	2 JAN 0425	342	0.00	0.00	0.00	0.
1 JAN 0740	93	0.00	0.00	0.00	0.	*	2 JAN 0430	343	0.00	0.00	0.00	0.
1 JAN 0745	94	0.00	0.00	0.00	0.	*	2 JAN 0435	344	0.00	0.00	0.00	0.
1 JAN 0750	95	0.00	0.00	0.00	0.	*	2 JAN 0440	345	0.00	0.00	0.00	0.
1 JAN 0755	96	0.00	0.00	0.00	0.	*	2 JAN 0445	346	0.00	0.00	0.00	0.
1 JAN 0800	97	0.00	0.00	0.00	0.	*	2 JAN 0450	347	0.00	0.00	0.00	0.
1 JAN 0805	98	0.00	0.00	0.00	0.	*	2 JAN 0455	348	0.00	0.00	0.00	0.
1 JAN 0810	99	0.00	0.00	0.00	0.	*	2 JAN 0500	349	0.00	0.00	0.00	0.
1 JAN 0815	100	0.00	0.00	0.00	0.	*	2 JAN 0505	350	0.00	0.00	0.00	0.
1 JAN 0820	101	0.00	0.00	0.00	0.	*	2 JAN 0510	351	0.00	0.00	0.00	0.
1 JAN 0825	102	0.00	0.00	0.00	0.	*	2 JAN 0515	352	0.00	0.00	0.00	0.
1 JAN 0830	103	0.00	0.00	0.00	0.	*	2 JAN 0520	353	0.00	0.00	0.00	0.
1 JAN 0835	104	0.00	0.00	0.00	0.	*	2 JAN 0525	354	0.00	0.00	0.00	0.
1 JAN 0840	105	0.00	0.00	0.00	0.	*	2 JAN 0530	355	0.00	0.00	0.00	0.
1 JAN 0845	106	0.01	0.01	0.00	0.	*	2 JAN 0535	356	0.00	0.00	0.00	0.
1 JAN 0850	107	0.01	0.01	0.00	0.	*	2 JAN 0540	357	0.00	0.00	0.00	0.

1 JAN 1150	143	0.17	0.15	0.02	0.	*	2 JAN 0840	393	0.00	0.00	0.00	0.
1 JAN 1155	144	0.22	0.17	0.05	1.	*	2 JAN 0845	394	0.00	0.00	0.00	0.
1 JAN 1200	145	0.16	0.12	0.05	2.	*	2 JAN 0850	395	0.00	0.00	0.00	0.
1 JAN 1205	146	0.03	0.02	0.01	3.	*	2 JAN 0855	396	0.00	0.00	0.00	0.
1 JAN 1210	147	0.03	0.02	0.01	5.	*	2 JAN 0900	397	0.00	0.00	0.00	0.
1 JAN 1215	148	0.03	0.02	0.01	8.	*	2 JAN 0905	398	0.00	0.00	0.00	0.
1 JAN 1220	149	0.02	0.02	0.01	11.	*	2 JAN 0910	399	0.00	0.00	0.00	0.
1 JAN 1225	150	0.02	0.01	0.01	15.	*	2 JAN 0915	400	0.00	0.00	0.00	0.
1 JAN 1230	151	0.02	0.01	0.01	18.	*	2 JAN 0920	401	0.00	0.00	0.00	0.
1 JAN 1235	152	0.01	0.01	0.01	22.	*	2 JAN 0925	402	0.00	0.00	0.00	0.
1 JAN 1240	153	0.01	0.01	0.01	25.	*	2 JAN 0930	403	0.00	0.00	0.00	0.
1 JAN 1245	154	0.01	0.01	0.01	28.	*	2 JAN 0935	404	0.00	0.00	0.00	0.
1 JAN 1250	155	0.01	0.01	0.00	30.	*	2 JAN 0940	405	0.00	0.00	0.00	0.
1 JAN 1255	156	0.01	0.01	0.00	31.	*	2 JAN 0945	406	0.00	0.00	0.00	0.
1 JAN 1300	157	0.01	0.01	0.00	32.	*	2 JAN 0950	407	0.00	0.00	0.00	0.
1 JAN 1305	158	0.01	0.01	0.00	32.	*	2 JAN 0955	408	0.00	0.00	0.00	0.
1 JAN 1310	159	0.01	0.01	0.00	32.	*	2 JAN 1000	409	0.00	0.00	0.00	0.
1 JAN 1315	160	0.01	0.01	0.00	31.	*	2 JAN 1005	410	0.00	0.00	0.00	0.
1 JAN 1320	161	0.01	0.01	0.00	30.	*	2 JAN 1010	411	0.00	0.00	0.00	0.
1 JAN 1325	162	0.01	0.01	0.00	29.	*	2 JAN 1015	412	0.00	0.00	0.00	0.
1 JAN 1330	163	0.01	0.00	0.00	27.	*	2 JAN 1020	413	0.00	0.00	0.00	0.
1 JAN 1335	164	0.01	0.00	0.00	26.	*	2 JAN 1025	414	0.00	0.00	0.00	0.
1 JAN 1340	165	0.01	0.00	0.00	24.	*	2 JAN 1030	415	0.00	0.00	0.00	0.
1 JAN 1345	166	0.01	0.00	0.00	23.	*	2 JAN 1035	416	0.00	0.00	0.00	0.
1 JAN 1350	167	0.01	0.00	0.00	21.	*	2 JAN 1040	417	0.00	0.00	0.00	0.
1 JAN 1355	168	0.01	0.00	0.00	20.	*	2 JAN 1045	418	0.00	0.00	0.00	0.
1 JAN 1400	169	0.01	0.00	0.00	19.	*	2 JAN 1050	419	0.00	0.00	0.00	0.
1 JAN 1405	170	0.01	0.00	0.00	18.	*	2 JAN 1055	420	0.00	0.00	0.00	0.
1 JAN 1410	171	0.01	0.00	0.00	17.	*	2 JAN 1100	421	0.00	0.00	0.00	0.
1 JAN 1415	172	0.01	0.00	0.00	16.	*	2 JAN 1105	422	0.00	0.00	0.00	0.
1 JAN 1420	173	0.01	0.00	0.00	16.	*	2 JAN 1110	423	0.00	0.00	0.00	0.
1 JAN 1425	174	0.01	0.00	0.00	15.	*	2 JAN 1115	424	0.00	0.00	0.00	0.
1 JAN 1430	175	0.01	0.00	0.00	14.	*	2 JAN 1120	425	0.00	0.00	0.00	0.
1 JAN 1435	176	0.01	0.00	0.00	14.	*	2 JAN 1125	426	0.00	0.00	0.00	0.
1 JAN 1440	177	0.01	0.00	0.00	13.	*	2 JAN 1130	427	0.00	0.00	0.00	0.

1 JAN 1740	213	0.00	0.00	0.00	6.	*	2 JAN 1430	463	0.00	0.00	0.00	0.
1 JAN 1745	214	0.00	0.00	0.00	5.	*	2 JAN 1435	464	0.00	0.00	0.00	0.
1 JAN 1750	215	0.00	0.00	0.00	5.	*	2 JAN 1440	465	0.00	0.00	0.00	0.
1 JAN 1755	216	0.00	0.00	0.00	5.	*	2 JAN 1445	466	0.00	0.00	0.00	0.
1 JAN 1800	217	0.00	0.00	0.00	5.	*	2 JAN 1450	467	0.00	0.00	0.00	0.
1 JAN 1805	218	0.00	0.00	0.00	5.	*	2 JAN 1455	468	0.00	0.00	0.00	0.
1 JAN 1810	219	0.00	0.00	0.00	5.	*	2 JAN 1500	469	0.00	0.00	0.00	0.
1 JAN 1815	220	0.00	0.00	0.00	5.	*	2 JAN 1505	470	0.00	0.00	0.00	0.
1 JAN 1820	221	0.00	0.00	0.00	5.	*	2 JAN 1510	471	0.00	0.00	0.00	0.
1 JAN 1825	222	0.00	0.00	0.00	5.	*	2 JAN 1515	472	0.00	0.00	0.00	0.
1 JAN 1830	223	0.00	0.00	0.00	5.	*	2 JAN 1520	473	0.00	0.00	0.00	0.
1 JAN 1835	224	0.00	0.00	0.00	5.	*	2 JAN 1525	474	0.00	0.00	0.00	0.
1 JAN 1840	225	0.00	0.00	0.00	5.	*	2 JAN 1530	475	0.00	0.00	0.00	0.
1 JAN 1845	226	0.00	0.00	0.00	5.	*	2 JAN 1535	476	0.00	0.00	0.00	0.
1 JAN 1850	227	0.00	0.00	0.00	5.	*	2 JAN 1540	477	0.00	0.00	0.00	0.
1 JAN 1855	228	0.00	0.00	0.00	5.	*	2 JAN 1545	478	0.00	0.00	0.00	0.
1 JAN 1900	229	0.00	0.00	0.00	5.	*	2 JAN 1550	479	0.00	0.00	0.00	0.
1 JAN 1905	230	0.00	0.00	0.00	5.	*	2 JAN 1555	480	0.00	0.00	0.00	0.
1 JAN 1910	231	0.00	0.00	0.00	5.	*	2 JAN 1600	481	0.00	0.00	0.00	0.
1 JAN 1915	232	0.00	0.00	0.00	5.	*	2 JAN 1605	482	0.00	0.00	0.00	0.
1 JAN 1920	233	0.00	0.00	0.00	5.	*	2 JAN 1610	483	0.00	0.00	0.00	0.
1 JAN 1925	234	0.00	0.00	0.00	4.	*	2 JAN 1615	484	0.00	0.00	0.00	0.
1 JAN 1930	235	0.00	0.00	0.00	4.	*	2 JAN 1620	485	0.00	0.00	0.00	0.
1 JAN 1935	236	0.00	0.00	0.00	4.	*	2 JAN 1625	486	0.00	0.00	0.00	0.
1 JAN 1940	237	0.00	0.00	0.00	4.	*	2 JAN 1630	487	0.00	0.00	0.00	0.
1 JAN 1945	238	0.00	0.00	0.00	4.	*	2 JAN 1635	488	0.00	0.00	0.00	0.
1 JAN 1950	239	0.00	0.00	0.00	4.	*	2 JAN 1640	489	0.00	0.00	0.00	0.
1 JAN 1955	240	0.00	0.00	0.00	4.	*	2 JAN 1645	490	0.00	0.00	0.00	0.
1 JAN 2000	241	0.00	0.00	0.00	4.	*	2 JAN 1650	491	0.00	0.00	0.00	0.
1 JAN 2005	242	0.00	0.00	0.00	4.	*	2 JAN 1655	492	0.00	0.00	0.00	0.
1 JAN 2010	243	0.00	0.00	0.00	4.	*	2 JAN 1700	493	0.00	0.00	0.00	0.
1 JAN 2015	244	0.00	0.00	0.00	4.	*	2 JAN 1705	494	0.00	0.00	0.00	0.
1 JAN 2020	245	0.00	0.00	0.00	4.	*	2 JAN 1710	495	0.00	0.00	0.00	0.
1 JAN 2025	246	0.00	0.00	0.00	4.	*	2 JAN 1715	496	0.00	0.00	0.00	0.
1 JAN 2030	247	0.00	0.00	0.00	4.	*	2 JAN 1720	497	0.00	0.00	0.00	0.

1 JAN 0005	2	0.	*	1 JAN 1030	127	0.	*	1 JAN 2055	252	4.	*	2 JAN 0720	377	0.
1 JAN 0010	3	0.	*	1 JAN 1035	128	0.	*	1 JAN 2100	253	4.	*	2 JAN 0725	378	0.
1 JAN 0015	4	0.	*	1 JAN 1040	129	0.	*	1 JAN 2105	254	4.	*	2 JAN 0730	379	0.
1 JAN 0020	5	0.	*	1 JAN 1045	130	0.	*	1 JAN 2110	255	4.	*	2 JAN 0735	380	0.
1 JAN 0025	6	0.	*	1 JAN 1050	131	0.	*	1 JAN 2115	256	4.	*	2 JAN 0740	381	0.
1 JAN 0030	7	0.	*	1 JAN 1055	132	0.	*	1 JAN 2120	257	4.	*	2 JAN 0745	382	0.
1 JAN 0035	8	0.	*	1 JAN 1100	133	0.	*	1 JAN 2125	258	3.	*	2 JAN 0750	383	0.
1 JAN 0040	9	0.	*	1 JAN 1105	134	0.	*	1 JAN 2130	259	3.	*	2 JAN 0755	384	0.
1 JAN 0045	10	0.	*	1 JAN 1110	135	0.	*	1 JAN 2135	260	3.	*	2 JAN 0800	385	0.
1 JAN 0050	11	0.	*	1 JAN 1115	136	0.	*	1 JAN 2140	261	3.	*	2 JAN 0805	386	0.
1 JAN 0055	12	0.	*	1 JAN 1120	137	0.	*	1 JAN 2145	262	3.	*	2 JAN 0810	387	0.
1 JAN 0100	13	0.	*	1 JAN 1125	138	0.	*	1 JAN 2150	263	3.	*	2 JAN 0815	388	0.
1 JAN 0105	14	0.	*	1 JAN 1130	139	0.	*	1 JAN 2155	264	3.	*	2 JAN 0820	389	0.
1 JAN 0110	15	0.	*	1 JAN 1135	140	0.	*	1 JAN 2200	265	3.	*	2 JAN 0825	390	0.
1 JAN 0115	16	0.	*	1 JAN 1140	141	0.	*	1 JAN 2205	266	3.	*	2 JAN 0830	391	0.
1 JAN 0120	17	0.	*	1 JAN 1145	142	0.	*	1 JAN 2210	267	3.	*	2 JAN 0835	392	0.
1 JAN 0125	18	0.	*	1 JAN 1150	143	0.	*	1 JAN 2215	268	3.	*	2 JAN 0840	393	0.
1 JAN 0130	19	0.	*	1 JAN 1155	144	1.	*	1 JAN 2220	269	3.	*	2 JAN 0845	394	0.
1 JAN 0135	20	0.	*	1 JAN 1200	145	2.	*	1 JAN 2225	270	3.	*	2 JAN 0850	395	0.
1 JAN 0140	21	0.	*	1 JAN 1205	146	3.	*	1 JAN 2230	271	3.	*	2 JAN 0855	396	0.
1 JAN 0145	22	0.	*	1 JAN 1210	147	5.	*	1 JAN 2235	272	3.	*	2 JAN 0900	397	0.
1 JAN 0150	23	0.	*	1 JAN 1215	148	8.	*	1 JAN 2240	273	3.	*	2 JAN 0905	398	0.
1 JAN 0155	24	0.	*	1 JAN 1220	149	11.	*	1 JAN 2245	274	3.	*	2 JAN 0910	399	0.
1 JAN 0200	25	0.	*	1 JAN 1225	150	15.	*	1 JAN 2250	275	3.	*	2 JAN 0915	400	0.
1 JAN 0205	26	0.	*	1 JAN 1230	151	18.	*	1 JAN 2255	276	3.	*	2 JAN 0920	401	0.
1 JAN 0210	27	0.	*	1 JAN 1235	152	22.	*	1 JAN 2300	277	3.	*	2 JAN 0925	402	0.
1 JAN 0215	28	0.	*	1 JAN 1240	153	25.	*	1 JAN 2305	278	3.	*	2 JAN 0930	403	0.
1 JAN 0220	29	0.	*	1 JAN 1245	154	28.	*	1 JAN 2310	279	3.	*	2 JAN 0935	404	0.
1 JAN 0225	30	0.	*	1 JAN 1250	155	30.	*	1 JAN 2315	280	3.	*	2 JAN 0940	405	0.
1 JAN 0230	31	0.	*	1 JAN 1255	156	31.	*	1 JAN 2320	281	3.	*	2 JAN 0945	406	0.
1 JAN 0235	32	0.	*	1 JAN 1300	157	32.	*	1 JAN 2325	282	3.	*	2 JAN 0950	407	0.
1 JAN 0240	33	0.	*	1 JAN 1305	158	32.	*	1 JAN 2330	283	3.	*	2 JAN 0955	408	0.
1 JAN 0245	34	0.	*	1 JAN 1310	159	32.	*	1 JAN 2335	284	3.	*	2 JAN 1000	409	0.
1 JAN 0250	35	0.	*	1 JAN 1315	160	31.	*	1 JAN 2340	285	3.	*	2 JAN 1005	410	0.
1 JAN 0255	36	0.	*	1 JAN 1320	161	30.	*	1 JAN 2345	286	3.	*	2 JAN 1010	411	0.

1 JAN 0555	72	0.	*	1 JAN 1620	197	7.	*	2 JAN 0245	322	0.	*	2 JAN 1310	447	0.
1 JAN 0600	73	0.	*	1 JAN 1625	198	7.	*	2 JAN 0250	323	0.	*	2 JAN 1315	448	0.
1 JAN 0605	74	0.	*	1 JAN 1630	199	7.	*	2 JAN 0255	324	0.	*	2 JAN 1320	449	0.
1 JAN 0610	75	0.	*	1 JAN 1635	200	7.	*	2 JAN 0300	325	0.	*	2 JAN 1325	450	0.
1 JAN 0615	76	0.	*	1 JAN 1640	201	7.	*	2 JAN 0305	326	0.	*	2 JAN 1330	451	0.
1 JAN 0620	77	0.	*	1 JAN 1645	202	7.	*	2 JAN 0310	327	0.	*	2 JAN 1335	452	0.
1 JAN 0625	78	0.	*	1 JAN 1650	203	6.	*	2 JAN 0315	328	0.	*	2 JAN 1340	453	0.
1 JAN 0630	79	0.	*	1 JAN 1655	204	6.	*	2 JAN 0320	329	0.	*	2 JAN 1345	454	0.
1 JAN 0635	80	0.	*	1 JAN 1700	205	6.	*	2 JAN 0325	330	0.	*	2 JAN 1350	455	0.
1 JAN 0640	81	0.	*	1 JAN 1705	206	6.	*	2 JAN 0330	331	0.	*	2 JAN 1355	456	0.
1 JAN 0645	82	0.	*	1 JAN 1710	207	6.	*	2 JAN 0335	332	0.	*	2 JAN 1400	457	0.
1 JAN 0650	83	0.	*	1 JAN 1715	208	6.	*	2 JAN 0340	333	0.	*	2 JAN 1405	458	0.
1 JAN 0655	84	0.	*	1 JAN 1720	209	6.	*	2 JAN 0345	334	0.	*	2 JAN 1410	459	0.
1 JAN 0700	85	0.	*	1 JAN 1725	210	6.	*	2 JAN 0350	335	0.	*	2 JAN 1415	460	0.
1 JAN 0705	86	0.	*	1 JAN 1730	211	6.	*	2 JAN 0355	336	0.	*	2 JAN 1420	461	0.
1 JAN 0710	87	0.	*	1 JAN 1735	212	6.	*	2 JAN 0400	337	0.	*	2 JAN 1425	462	0.
1 JAN 0715	88	0.	*	1 JAN 1740	213	6.	*	2 JAN 0405	338	0.	*	2 JAN 1430	463	0.
1 JAN 0720	89	0.	*	1 JAN 1745	214	5.	*	2 JAN 0410	339	0.	*	2 JAN 1435	464	0.
1 JAN 0725	90	0.	*	1 JAN 1750	215	5.	*	2 JAN 0415	340	0.	*	2 JAN 1440	465	0.
1 JAN 0730	91	0.	*	1 JAN 1755	216	5.	*	2 JAN 0420	341	0.	*	2 JAN 1445	466	0.
1 JAN 0735	92	0.	*	1 JAN 1800.	217	5.	*	2 JAN 0425	342	0.	*	2 JAN 1450	467	0.
1 JAN 0740	93	0.	*	1 JAN 1805	218	5.	*	2 JAN 0430	343	0.	*	2 JAN 1455	468	0.
1 JAN 0745	94	0.	*	1 JAN 1810	219	5.	*	2 JAN 0435	344	0.	*	2 JAN 1500	469	0.
1 JAN 0750	95	0.	*	1 JAN 1815	220	5.	*	2 JAN 0440	345	0.	*	2 JAN 1505	470	0.
1 JAN 0755	96	0.	*	1 JAN 1820	221	5.	*	2 JAN 0445	346	0.	*	2 JAN 1510	471	0.
1 JAN 0800	97	0.	*	1 JAN 1825	222	5.	*	2 JAN 0450	347	0.	*	2 JAN 1515	472	0.
1 JAN 0805	98	0.	*	1 JAN 1830	223	5.	*	2 JAN 0455	348	0.	*	2 JAN 1520	473	0.
1 JAN 0810	99	0.	*	1 JAN 1835	224	5.	*	2 JAN 0500	349	0.	*	2 JAN 1525	474	0.
1 JAN 0815	100	0.	*	1 JAN 1840	225	5.	*	2 JAN 0505	350	0.	*	2 JAN 1530	475	0.
1 JAN 0820	101	0.	*	1 JAN 1845	226	5.	*	2 JAN 0510	351	0.	*	2 JAN 1535	476	0.
1 JAN 0825	102	0.	*	1 JAN 1850	227	5.	*	2 JAN 0515	352	0.	*	2 JAN 1540	477	0.
1 JAN 0830	103	0.	*	1 JAN 1855	228	5.	*	2 JAN 0520	353	0.	*	2 JAN 1545	478	0.
1 JAN 0835	104	0.	*	1 JAN 1900	229	5.	*	2 JAN 0525	354	0.	*	2 JAN 1550	479	0.
1 JAN 0840	105	0.	*	1 JAN 1905	230	5.	*	2 JAN 0530	355	0.	*	2 JAN 1555	480	0.
1 JAN 0845	106	0.	*	1 JAN 1910	231	5.	*	2 JAN 0535	356	0.	*	2 JAN 1600	481	0.

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                            IOUT          22  SAVE HYDROGRAPH ON THIS UNIT
                           ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                           ISAV2         500  LAST ORDINATE PUNCHED OR SAVED
                          TIMINT       0.083  TIME INTERVAL IN HOURS

   45 IN             TIME DATA FOR INPUT TIME SERIES
                           JXMIN           6  TIME INTERVAL IN MINUTES
                          JXDATE      1JAN94  STARTING DATE
                          JXTIME           0  STARTING TIME

                    SUBBASIN RUNOFF DATA

   43 BA             SUBBASIN CHARACTERISTICS
                           TAREA,       1.50  SUBBASIN AREA

                     PRECIPITATION DATA

   44 PB                   STORM        2.08  BASIN TOTAL PRECIPITATION

   46 PI               INCREMENTAL PRECIPITATION PATTERN
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.01     0.01
                        0.01     0.01     0.01     0.01     0.01     0.01     0.01     0.01
 0.02     0.04
                        0.05     0.08     0.11     0.08     0.02     0.01     0.01     0.01
 0.01     0.01
                        0.01     0.01     0.01     0.01     0.01     0.01     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
                        0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
 0.00     0.00
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      1 JAN 0055   12    0.00     0.00     0.00          0.       *       1 JAN 2145   262     0.00
0.00    0.00        13.
      1 JAN 0100   13    0.00     0.00     0.00          0.       *       1 JAN 2150   263     0.00
0.00    0.00        13.
      1 JAN 0105   14    0.00     0.00     0.00          0.       *       1 JAN 2155   264     0.00
0.00    0.00        13.
      1 JAN 0110   15    0.00     0.00     0.00          0.       *       1 JAN 2200   265     0.00
0.00    0.00        13.
      1 JAN 0115   16    0.00     0.00     0.00          0.       *       1 JAN 2205   266     0.00
0.00    0.00        13.
      1 JAN 0120   17    0.00     0.00     0.00          0.       *       1 JAN 2210   267     0.00
0.00    0.00        13.
      1 JAN 0125   18    0.00     0.00     0.00          0.       *       1 JAN 2215   268     0.00
0.00    0.00        12.
      1 JAN 0130   19    0.00     0.00     0.00          0.       *       1 JAN 2220   269     0.00
0.00    0.00        12.
      1 JAN 0135   20    0.00     0.00     0.00          0.       *       1 JAN 2225   270     0.00
0.00    0.00        12.
      1 JAN 0140   21    0.00     0.00     0.00          0.       *       1 JAN 2230   271     0.00
0.00    0.00        12.
      1 JAN 0145   22    0.00     0.00     0.00          0.       *       1 JAN 2235   272     0.00
0.00    0.00        12.
      1 JAN 0150   23    0.00     0.00     0.00          0.       *       1 JAN 2240   273     0.00
0.00    0.00        12.
      1 JAN 0155   24    0.00     0.00     0.00          0.       *       1 JAN 2245   274     0.00
0.00    0.00        12.
      1 JAN 0200   25    0.00     0.00     0.00          0.       *       1 JAN 2250   275     0.00
0.00    0.00        12.
      1 JAN 0205   26    0.00     0.00     0.00          0.       *       1 JAN 2255   276     0.00
0.00    0.00        12.
      1 JAN 0210   27    0.00     0.00     0.00          0.       *       1 JAN 2300   277     0.00
0.00    0.00        12.
      1 JAN 0215   28    0.00     0.00     0.00          0.       *       1 JAN 2305   278     0.00
0.00    0.00        12.
      1 JAN 0220   29    0.00     0.00     0.00          0.       *       1 JAN 2310   279     0.00
0.00    0.00        12.
      1 JAN 0225   30    0.00     0.00     0.00          0.       *       1 JAN 2315   280     0.00
0.00    0.00        12.
      1 JAN 0230   31    0.00     0.00     0.00          0.       *       1 JAN 2320   281     0.00
0.00    0.00        12.
      1 JAN 0235   32    0.00     0.00     0.00          0.       *       1 JAN 2325   282     0.00
0.00    0.00        12.
      1 JAN 0240   33    0.00     0.00     0.00          0.       *       1 JAN 2330   283     0.00
0.00    0.00        12.
      1 JAN 0245   34    0.00     0.00     0.00          0.       *       1 JAN 2335   284     0.00
0.00    0.00        12.
      1 JAN 0250   35    0.00     0.00     0.00          0.       *       1 JAN 2340   285     0.00
0.00    0.00        12.
      1 JAN 0255   36    0.00     0.00     0.00          0.       *       1 JAN 2345   286     0.00
0.00    0.00        12.
      1 JAN 0300   37    0.00     0.00     0.00          0.       *       1 JAN 2350   287     0.00
0.00    0.00        12.
      1 JAN 0305   38    0.00     0.00     0.00          0.       *       1 JAN 2355   288     0.00
0.00    0.00        12.
      1 JAN 0310   39    0.00     0.00     0.00          0.       *       2 JAN 0000   289     0.00
0.00    0.00        12.
      1 JAN 0315   40    0.00     0.00     0.00          0.       *       2 JAN 0005   290     0.00
0.00    0.00        12.
      1 JAN 0320   41    0.00     0.00     0.00          0.       *       2 JAN 0010   291     0.00
0.00    0.00        12.
      1 JAN 0325   42    0.00     0.00     0.00          0.       *       2 JAN 0015   292     0.00
0.00    0.00        11.
      1 JAN 0330   43    0.00     0.00     0.00          0.       *       2 JAN 0020   293     0.00
0.00    0.00        11.
      1 JAN 0335   44    0.00     0.00     0.00          0.       *       2 JAN 0025   294     0.00
0.00    0.00        11.
      1 JAN 0340   45    0.00     0.00     0.00          0.       *       2 JAN 0030   295     0.00
0.00    0.00        11.
      1 JAN 0345   46    0.00     0.00     0.00          0.       *       2 JAN 0035   296     0.00
0.00    0.00        10.
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1 JAN	0645	82	0.00	0.00	0.00	0.	*	2 JAN 0335	332	0.00	0.00	0.00	0.
1 JAN	0650	83	0.00	0.00	0.00	0.	*	2 JAN 0340	333	0.00	0.00	0.00	0.
1 JAN	0655	84	0.00	0.00	0.00	0.	*	2 JAN 0345	334	0.00	0.00	0.00	0.
1 JAN	0700	85	0.00	0.00	0.00	0.	*	2 JAN 0350	335	0.00	0.00	0.00	0.
1 JAN	0705	86	0.00	0.00	0.00	0.	*	2 JAN 0355	336	0.00	0.00	0.00	0.
1 JAN	0710	87	0.00	0.00	0.00	0.	*	2 JAN 0400	337	0.00	0.00	0.00	0.
1 JAN	0715	88	0.00	0.00	0.00	0.	*	2 JAN 0405	338	0.00	0.00	0.00	0.
1 JAN	0720	89	0.00	0.00	0.00	0.	*	2 JAN 0410	339	0.00	0.00	0.00	0.
1 JAN	0725	90	0.00	0.00	0.00	0.	*	2 JAN 0415	340	0.00	0.00	0.00	0.
1 JAN	0730	91	0.00	0.00	0.00	0.	*	2 JAN 0420	341	0.00	0.00	0.00	0.
1 JAN	0735	92	0.00	0.00	0.00	0.	*	2 JAN 0425	342	0.00	0.00	0.00	0.
1 JAN	0740	93	0.00	0.00	0.00	0.	*	2 JAN 0430	343	0.00	0.00	0.00	0.
1 JAN	0745	94	0.00	0.00	0.00	0.	*	2 JAN 0435	344	0.00	0.00	0.00	0.
1 JAN	0750	95	0.00	0.00	0.00	0.	*	2 JAN 0440	345	0.00	0.00	0.00	0.
1 JAN	0755	96	0.00	0.00	0.00	0.	*	2 JAN 0445	346	0.00	0.00	0.00	0.
1 JAN	0800	97	0.00	0.00	0.00	0.	*	2 JAN 0450	347	0.00	0.00	0.00	0.
1 JAN	0805	98	0.00	0.00	0.00	0.	*	2 JAN 0455	348	0.00	0.00	0.00	0.
1 JAN	0810	99	0.00	0.00	0.00	0.	*	2 JAN 0500	349	0.00	0.00	0.00	0.
1 JAN	0815	100	0.00	0.00	0.00	0.	*	2 JAN 0505	350	0.00	0.00	0.00	0.
1 JAN	0820	101	0.00	0.00	0.00	0.	*	2 JAN 0510	351	0.00	0.00	0.00	0.
1 JAN	0825	102	0.00	0.00	0.00	0.	*	2 JAN 0515	352	0.00	0.00	0.00	0.
1 JAN	0830	103	0.00	0.00	0.00	0.	*	2 JAN 0520	353	0.00	0.00	0.00	0.
1 JAN	0835	104	0.00	0.00	0.00	0.	*	2 JAN 0525	354	0.00	0.00	0.00	0.
1 JAN	0840	105	0.00	0.00	0.00	0.	*	2 JAN 0530	355	0.00	0.00	0.00	0.
1 JAN	0845	106	0.01	0.01	0.00	0.	*	2 JAN 0535	356	0.00	0.00	0.00	0.
1 JAN	0850	107	0.01	0.01	0.00	0.	*	2 JAN 0540	357	0.00	0.00	0.00	0.
1 JAN	0855	108	0.01	0.01	0.00	0.	*	2 JAN 0545	358	0.00	0.00	0.00	0.
1 JAN	0900	109	0.01	0.01	0.00	0.	*	2 JAN 0550	359	0.00	0.00	0.00	0.
1 JAN	0905	110	0.01	0.01	0.00	0.	*	2 JAN 0555	360	0.00	0.00	0.00	0.
1 JAN	0910	111	0.01	0.01	0.00	0.	*	2 JAN 0600	361	0.00	0.00	0.00	0.
1 JAN	0915	112	0.01	0.01	0.00	0.	*	2 JAN 0605	362	0.00	0.00	0.00	0.
1 JAN	0920	113	0.01	0.01	0.00	0.	*	2 JAN 0610	363	0.00	0.00	0.00	0.
1 JAN	0925	114	0.01	0.01	0.00	0.	*	2 JAN 0615	364	0.00	0.00	0.00	0.
1 JAN	0930	115	0.01	0.01	0.00	0.	*	2 JAN 0620	365	0.00	0.00	0.00	0.
1 JAN	0935	116	0.01	0.01	0.00	0.	*	2 JAN 0625	366	0.00	0.00	0.00	0.

1 JAN 1235	152	0.01	0.01	0.01	83.	*	2 JAN 0925	402	0.00	0.00	0.00	0.
1 JAN 1240	153	0.01	0.01	0.01	95.	*	2 JAN 0930	403	0.00	0.00	0.00	0.
1 JAN 1245	154	0.01	0.01	0.01	105.	*	2 JAN 0935	404	0.00	0.00	0.00	0.
1 JAN 1250	155	0.01	0.01	0.00	112.	*	2 JAN 0940	405	0.00	0.00	0.00	0.
1 JAN 1255	156	0.01	0.01	0.00	117.	*	2 JAN 0945	406	0.00	0.00	0.00	0.
1 JAN 1300	157	0.01	0.01	0.00	120.	*	2 JAN 0950	407	0.00	0.00	0.00	0.
1 JAN 1305	158	0.01	0.01	0.00	121.	*	2 JAN 0955	408	0.00	0.00	0.00	0.
1 JAN 1310	159	0.01	0.01	0.00	120.	*	2 JAN 1000	409	0.00	0.00	0.00	0.
1 JAN 1315	160	0.01	0.01	0.00	118.	*	2 JAN 1005	410	0.00	0.00	0.00	0.
1 JAN 1320	161	0.01	0.01	0.00	114.	*	2 JAN 1010	411	0.00	0.00	0.00	0.
1 JAN 1325	162	0.01	0.01	0.00	108.	*	2 JAN 1015	412	0.00	0.00	0.00	0.
1 JAN 1330	163	0.01	0.00	0.00	102.	*	2 JAN 1020	413	0.00	0.00	0.00	0.
1 JAN 1335	164	0.01	0.00	0.00	96.	*	2 JAN 1025	414	0.00	0.00	0.00	0.
1 JAN 1340	165	0.01	0.00	0.00	90.	*	2 JAN 1030	415	0.00	0.00	0.00	0.
1 JAN 1345	166	0.01	0.00	0.00	85.	*	2 JAN 1035	416	0.00	0.00	0.00	0.
1 JAN 1350	167	0.01	0.00	0.00	80.	*	2 JAN 1040	417	0.00	0.00	0.00	0.
1 JAN 1355	168	0.01	0.00	0.00	76.	*	2 JAN 1045	418	0.00	0.00	0.00	0.
1 JAN 1400	169	0.01	0.00	0.00	72.	*	2 JAN 1050	419	0.00	0.00	0.00	0.
1 JAN 1405	170	0.01	0.00	0.00	68.	*	2 JAN 1055	420	0.00	0.00	0.00	0.
1 JAN 1410	171	0.01	0.00	0.00	65.	*	2 JAN 1100	421	0.00	0.00	0.00	0.
1 JAN 1415	172	0.01	0.00	0.00	62.	*	2 JAN 1105	422	0.00	0.00	0.00	0.
1 JAN 1420	173	0.01	0.00	0.00	59.	*	2 JAN 1110	423	0.00	0.00	0.00	0.
1 JAN 1425	174	0.01	0.00	0.00	56.	*	2 JAN 1115	424	0.00	0.00	0.00	0.
1 JAN 1430	175	0.01	0.00	0.00	53.	*	2 JAN 1120	425	0.00	0.00	0.00	0.
1 JAN 1435	176	0.01	0.00	0.00	51.	*	2 JAN 1125	426	0.00	0.00	0.00	0.
1 JAN 1440	177	0.01	0.00	0.00	49.	*	2 JAN 1130	427	0.00	0.00	0.00	0.
1 JAN 1445	178	0.01	0.00	0.00	47.	*	2 JAN 1135	428	0.00	0.00	0.00	0.
1 JAN 1450	179	0.01	0.00	0.00	45.	*	2 JAN 1140	429	0.00	0.00	0.00	0.
1 JAN 1455	180	0.01	0.00	0.00	43.	*	2 JAN 1145	430	0.00	0.00	0.00	0.
1 JAN 1500	181	0.01	0.00	0.00	42.	*	2 JAN 1150	431	0.00	0.00	0.00	0.
1 JAN 1505	182	0.01	0.00	0.00	40.	*	2 JAN 1155	432	0.00	0.00	0.00	0.
1 JAN 1510	183	0.01	0.00	0.00	39.	*	2 JAN 1200	433	0.00	0.00	0.00	0.
1 JAN 1515	184	0.00	0.00	0.00	38.	*	2 JAN 1205	434	0.00	0.00	0.00	0.
1 JAN 1520	185	0.00	0.00	0.00	36.	*	2 JAN 1210	435	0.00	0.00	0.00	0.
1 JAN 1525	186	0.00	0.00	0.00	35.	*	2 JAN 1215	436	0.00	0.00	0.00	0.

1 JAN 1825	222	0.00	0.00	0.00	19.	*	2 JAN 1515	472	0.00	0.00	0.00	0.
1 JAN 1830	223	0.00	0.00	0.00	19.	*	2 JAN 1520	473	0.00	0.00	0.00	0.
1 JAN 1835	224	0.00	0.00	0.00	19.	*	2 JAN 1525	474	0.00	0.00	0.00	0.
1 JAN 1840	225	0.00	0.00	0.00	18.	*	2 JAN 1530	475	0.00	0.00	0.00	0.
1 JAN 1845	226	0.00	0.00	0.00	18.	*	2 JAN 1535	476	0.00	0.00	0.00	0.
1 JAN 1850	227	0.00	0.00	0.00	18.	*	2 JAN 1540	477	0.00	0.00	0.00	0.
1 JAN 1855	228	0.00	0.00	0.00	18.	*	2 JAN 1545	478	0.00	0.00	0.00	0.
1 JAN 1900	229	0.00	0.00	0.00	18.	*	2 JAN 1550	479	0.00	0.00	0.00	0.
1 JAN 1905	230	0.00	0.00	0.00	18.	*	2 JAN 1555	480	0.00	0.00	0.00	0.
1 JAN 1910	231	0.00	0.00	0.00	17.	*	2 JAN 1600	481	0.00	0.00	0.00	0.
1 JAN 1915	232	0.00	0.00	0.00	17.	*	2 JAN 1605	482	0.00	0.00	0.00	0.
1 JAN 1920	233	0.00	0.00	0.00	17.	*	2 JAN 1610	483	0.00	0.00	0.00	0.
1 JAN 1925	234	0.00	0.00	0.00	17.	*	2 JAN 1615	484	0.00	0.00	0.00	0.
1 JAN 1930	235	0.00	0.00	0.00	17.	*	2 JAN 1620	485	0.00	0.00	0.00	0.
1 JAN 1935	236	0.00	0.00	0.00	16.	*	2 JAN 1625	486	0.00	0.00	0.00	0.
1 JAN 1940	237	0.00	0.00	0.00	16.	*	2 JAN 1630	487	0.00	0.00	0.00	0.
1 JAN 1945	238	0.00	0.00	0.00	16.	*	2 JAN 1635	488	0.00	0.00	0.00	0.
1 JAN 1950	239	0.00	0.00	0.00	16.	*	2 JAN 1640	489	0.00	0.00	0.00	0.
1 JAN 1955	240	0.00	0.00	0.00	16.	*	2 JAN 1645	490	0.00	0.00	0.00	0.
1 JAN 2000	241	0.00	0.00	0.00	16.	*	2 JAN 1650	491	0.00	0.00	0.00	0.
1 JAN 2005	242	0.00	0.00	0.00	15.	*	2 JAN 1655	492	0.00	0.00	0.00	0.
1 JAN 2010	243	0.00	0.00	0.00	15.	*	2 JAN 1700	493	0.00	0.00	0.00	0.
1 JAN 2015	244	0.00	0.00	0.00	15.	*	2 JAN 1705	494	0.00	0.00	0.00	0.
1 JAN 2020	245	0.00	0.00	0.00	15.	*	2 JAN 1710	495	0.00	0.00	0.00	0.
1 JAN 2025	246	0.00	0.00	0.00	15.	*	2 JAN 1715	496	0.00	0.00	0.00	0.
1 JAN 2030	247	0.00	0.00	0.00	15.	*	2 JAN 1720	497	0.00	0.00	0.00	0.
1 JAN 2035	248	0.00	0.00	0.00	14.	*	2 JAN 1725	498	0.00	0.00	0.00	0.
1 JAN 2040	249	0.00	0.00	0.00	14.	*	2 JAN 1730	499	0.00	0.00	0.00	0.
1 JAN 2045	250	0.00	0.00	0.00	14.	*	2 JAN 1735	500	0.00	0.00	0.00	0.

TOTAL RAINFALL = 2.08, TOTAL LOSS = 1.66, TOTAL EXCESS = 0.42

	PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
				6-HR	24-HR	72-HR	41.58-HR
+	(CFS)	(HR)					
			(CFS)				
+	121.	13.08		51.	17.	10.	10.
			(INCHES)	0.316	0.421	0.421	0.421

1 JAN 0100	13	0.	*	1 JAN 1125	138	0.	*	1 JAN 2150	263	13.	*
2 JAN 0815	388	0.									
1 JAN 0105	14	0.	*	1 JAN 1130	139	0.	*	1 JAN 2155	264	13.	*
2 JAN 0820	389	0.									
1 JAN 0110	15	0.	*	1 JAN 1135	140	0.	*	1 JAN 2200	265	13.	*
2 JAN 0825	390	0.									
1 JAN 0115	16	0.	*	1 JAN 1140	141	0.	*	1 JAN 2205	266	13.	*
2 JAN 0830	391	0.									
1 JAN 0120	17	0.	*	1 JAN 1145	142	0.	*	1 JAN 2210	267	13.	*
2 JAN 0835	392	0.									
1 JAN 0125	18	0.	*	1 JAN 1150	143	1.	*	1 JAN 2215	268	12.	*
2 JAN 0840	393	0.									
1 JAN 0130	19	0.	*	1 JAN 1155	144	3.	*	1 JAN 2220	269	12.	*
2 JAN 0845	394	0.									
1 JAN 0135	20	0.	*	1 JAN 1200	145	6.	*	1 JAN 2225	270	12.	*
2 JAN 0850	395	0.									
1 JAN 0140	21	0.	*	1 JAN 1205	146	12.	*	1 JAN 2230	271	12.	*
2 JAN 0855	396	0.									
1 JAN 0145	22	0.	*	1 JAN 1210	147	19.	*	1 JAN 2235	272	12.	*
2 JAN 0900	397	0.									
1 JAN 0150	23	0.	*	1 JAN 1215	148	29.	*	1 JAN 2240	273	12.	*
2 JAN 0905	398	0.									
1 JAN 0155	24	0.	*	1 JAN 1220	149	41.	*	1 JAN 2245	274	12.	*
2 JAN 0910	399	0.									
1 JAN 0200	25	0.	*	1 JAN 1225	150	55.	*	1 JAN 2250	275	12.	*
2 JAN 0915	400	0.									
1 JAN 0205	26	0.	*	1 JAN 1230	151	69.	*	1 JAN 2255	276	12.	*
2 JAN 0920	401	0.									
1 JAN 0210	27	0.	*	1 JAN 1235	152	83.	*	1 JAN 2300	277	12.	*
2 JAN 0925	402	0.									
1 JAN 0215	28	0.	*	1 JAN 1240	153	95.	*	1 JAN 2305	278	12.	*
2 JAN 0930	403	0.									
1 JAN 0220	29	0.	*	1 JAN 1245	154	105.	*	1 JAN 2310	279	12.	*
2 JAN 0935	404	0.									
1 JAN 0225	30	0.	*	1 JAN 1250	155	112.	*	1 JAN 2315	280	12.	*
2 JAN 0940	405	0.									
1 JAN 0230	31	0.	*	1 JAN 1255	156	117.	*	1 JAN 2320	281	12.	*
2 JAN 0945	406	0.									
1 JAN 0235	32	0.	*	1 JAN 1300	157	120.	*	1 JAN 2325	282	12.	*
2 JAN 0950	407	0.									
1 JAN 0240	33	0.	*	1 JAN 1305	158	121.	*	1 JAN 2330	283	12.	*
2 JAN 0955	408	0.									
1 JAN 0245	34	0.	*	1 JAN 1310	159	120.	*	1 JAN 2335	284	12.	*
2 JAN 1000	409	0.									
1 JAN 0250	35	0.	*	1 JAN 1315	160	118.	*	1 JAN 2340	285	12.	*
2 JAN 1005	410	0.									
1 JAN 0255	36	0.	*	1 JAN 1320	161	114.	*	1 JAN 2345	286	12.	*
2 JAN 1010	411	0.									
1 JAN 0300	37	0.	*	1 JAN 1325	162	108.	*	1 JAN 2350	287	12.	*
2 JAN 1015	412	0.									
1 JAN 0305	38	0.	*	1 JAN 1330	163	102.	*	1 JAN 2355	288	12.	*
2 JAN 1020	413	0.									
1 JAN 0310	39	0.	*	1 JAN 1335	164	96.	*	2 JAN 0000	289	12.	*
2 JAN 1025	414	0.									
1 JAN 0315	40	0.	*	1 JAN 1340	165	90.	*	2 JAN 0005	290	12.	*
2 JAN 1030	415	0.									
1 JAN 0320	41	0.	*	1 JAN 1345	166	85.	*	2 JAN 0010	291	12.	*
2 JAN 1035	416	0.									
1 JAN 0325	42	0.	*	1 JAN 1350	167	80.	*	2 JAN 0015	292	11.	*
2 JAN 1040	417	0.									
1 JAN 0330	43	0.	*	1 JAN 1355	168	76.	*	2 JAN 0020	293	11.	*
2 JAN 1045	418	0.									
1 JAN 0335	44	0.	*	1 JAN 1400	169	72.	*	2 JAN 0025	294	11.	*
2 JAN 1050	419	0.									
1 JAN 0340	45	0.	*	1 JAN 1405	170	68.	*	2 JAN 0030	295	11.	*
2 JAN 1055	420	0.									
1 JAN 0345	46	0.	*	1 JAN 1410	171	65.	*	2 JAN 0035	296	10.	*
2 JAN 1100	421	0.									
1 JAN 0350	47	0.	*	1 JAN 1415	172	62.	*	2 JAN 0040	297	10.	*
2 JAN 1105	422	0.									

1 JAN 0650	83	0.	*	1 JAN 1715	208	22.	*	2 JAN 0340	333	0.	*	2 JAN 1405	458	0.
1 JAN 0655	84	0.	*	1 JAN 1720	209	22.	*	2 JAN 0345	334	0.	*	2 JAN 1410	459	0.
1 JAN 0700	85	0.	*	1 JAN 1725	210	22.	*	2 JAN 0350	335	0.	*	2 JAN 1415	460	0.
1 JAN 0705	86	0.	*	1 JAN 1730	211	21.	*	2 JAN 0355	336	0.	*	2 JAN 1420	461	0.
1 JAN 0710	87	0.	*	1 JAN 1735	212	21.	*	2 JAN 0400	337	0.	*	2 JAN 1425	462	0.
1 JAN 0715	88	0.	*	1 JAN 1740	213	21.	*	2 JAN 0405	338	0.	*	2 JAN 1430	463	0.
1 JAN 0720	89	0.	*	1 JAN 1745	214	21.	*	2 JAN 0410	339	0.	*	2 JAN 1435	464	0.
1 JAN 0725	90	0.	*	1 JAN 1750	215	20.	*	2 JAN 0415	340	0.	*	2 JAN 1440	465	0.
1 JAN 0730	91	0.	*	1 JAN 1755	216	20.	*	2 JAN 0420	341	0.	*	2 JAN 1445	466	0.
1 JAN 0735	92	0.	*	1 JAN 1800	217	20.	*	2 JAN 0425	342	0.	*	2 JAN 1450	467	0.
1 JAN 0740	93	0.	*	1 JAN 1805	218	20.	*	2 JAN 0430	343	0.	*	2 JAN 1455	468	0.
1 JAN 0745	94	0.	*	1 JAN 1810	219	20.	*	2 JAN 0435	344	0.	*	2 JAN 1500	469	0.
1 JAN 0750	95	0.	*	1 JAN 1815	220	19.	*	2 JAN 0440	345	0.	*	2 JAN 1505	470	0.
1 JAN 0755	96	0.	*	1 JAN 1820	221	19.	*	2 JAN 0445	346	0.	*	2 JAN 1510	471	0.
1 JAN 0800	97	0.	*	1 JAN 1825	222	19.	*	2 JAN 0450	347	0.	*	2 JAN 1515	472	0.
1 JAN 0805	98	0.	*	1 JAN 1830	223	19.	*	2 JAN 0455	348	0.	*	2 JAN 1520	473	0.
1 JAN 0810	99	0.	*	1 JAN 1835	224	19.	*	2 JAN 0500	349	0.	*	2 JAN 1525	474	0.
1 JAN 0815	100	0.	*	1 JAN 1840	225	18.	*	2 JAN 0505	350	0.	*	2 JAN 1530	475	0.
1 JAN 0820	101	0.	*	1 JAN 1845	226	18.	*	2 JAN 0510	351	0.	*	2 JAN 1535	476	0.
1 JAN 0825	102	0.	*	1 JAN 1850	227	18.	*	2 JAN 0515	352	0.	*	2 JAN 1540	477	0.
1 JAN 0830	103	0.	*	1 JAN 1855	228	18.	*	2 JAN 0520	353	0.	*	2 JAN 1545	478	0.
1 JAN 0835	104	0.	*	1 JAN 1900	229	18.	*	2 JAN 0525	354	0.	*	2 JAN 1550	479	0.
1 JAN 0840	105	0.	*	1 JAN 1905	230	18.	*	2 JAN 0530	355	0.	*	2 JAN 1555	480	0.
1 JAN 0845	106	0.	*	1 JAN 1910	231	17.	*	2 JAN 0535	356	0.	*	2 JAN 1600	481	0.
1 JAN 0850	107	0.	*	1 JAN 1915	232	17.	*	2 JAN 0540	357	0.	*	2 JAN 1605	482	0.
1 JAN 0855	108	0.	*	1 JAN 1920	233	17.	*	2 JAN 0545	358	0.	*	2 JAN 1610	483	0.
1 JAN 0900	109	0.	*	1 JAN 1925	234	17.	*	2 JAN 0550	359	0.	*	2 JAN 1615	484	0.
1 JAN 0905	110	0.	*	1 JAN 1930	235	17.	*	2 JAN 0555	360	0.	*	2 JAN 1620	485	0.
1 JAN 0910	111	0.	*	1 JAN 1935	236	16.	*	2 JAN 0600	361	0.	*	2 JAN 1625	486	0.
1 JAN 0915	112	0.	*	1 JAN 1940	237	16.	*	2 JAN 0605	362	0.	*	2 JAN 1630	487	0.
1 JAN 0920	113	0.	*	1 JAN 1945	238	16.	*	2 JAN 0610	363	0.	*	2 JAN 1635	488	0.
1 JAN 0925	114	0.	*	1 JAN 1950	239	16.	*	2 JAN 0615	364	0.	*	2 JAN 1640	489	0.
1 JAN 0930	115	0.	*	1 JAN 1955	240	16.	*	2 JAN 0620	365	0.	*	2 JAN 1645	490	0.
1 JAN 0935	116	0.	*	1 JAN 2000	241	16.	*	2 JAN 0625	366	0.	*	2 JAN 1650	491	0.
1 JAN 0940	117	0.	*	1 JAN 2005	242	15.	*	2 JAN 0630	367	0.	*	2 JAN 1655	492	0.

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

MAXIMUM STAGE +	TIME OF MAX STAGE	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA
+		HYDROGRAPH AT	SOUTH	32.	13.08	14.	5.	3.	0.40
+		ROUTED TO	2R	32.	13.08	14.	5.	3.	0.40
+		HYDROGRAPH AT	NORTH	121.	13.08	51.	17.	10.	1.50
+		ROUTED TO	1R	121.	13.08	51.	17.	10.	1.50

*** NORMAL END OF HEC-1 ***

peak discharges (cfs)

```
1*****************************************
***************************************
 *                                       *
*                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*    U.S. ARMY CORPS OF ENGINEERS      *
 *              MAY   1991               *
*    HYDROLOGIC ENGINEERING CENTER     *
 *            VERSION 4.0.1E             *
*          609 SECOND STREET           *
 *                                       *
*        DAVIS, CALIFORNIA 95616       *
 *  RUN DATE            TIME             *
*           (916) 551-1748             *
 *                                       *
*                                      *
 *****************************************
***************************************


                                                X       X  XXXXXXX   XXXXX          X
                                                X       X  X        X     X        XX
                                                X       X  X        X               X
                                                XXXXXXX  XXXX       X        XXXXX  X
                                                X       X  X        X               X
                                                X       X  X        X     X         X
                                                X       X  XXXXXXX   XXXXX         XXX


          THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73),
HEC1GS, HEC1DB, AND HEC1KW.

          THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED
WITH THE 1973-STYLE INPUT STRUCTURE.
          THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP
81. THIS IS THE FORTRAN77 VERSION
          NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION,
DSS:WRITE STAGE FREQUENCY,
          DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND
AMPT INFILTRATION
          KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


                                                       HEC-1 INPUT
PAGE  1

         LINE
ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              1          ID  HEC-1 Analysis using WMS
              2          ID
              3          ID
                         *DIAGRAM
              4          IT      15  1JAN94       0      150
              5          IO       0

              6          KK   CELL2
              7          KO       0       0     0.0       0      22
              8          BA   0.183
              9          PB    2.08
             10          IN       6  1JAN94       0
                         * typeII-24hour
             11          PC     0.0   0.001   0.002  0.0031  0.0041  0.0051  0.0062
0.0073  0.0083  0.0094
             12          PC  0.0105  0.0116  0.0127  0.0138   0.015  0.0161  0.0173
0.0185  0.0196  0.0208
             13          PC   0.022  0.0232  0.0244  0.0256  0.0269  0.0281  0.0294
0.0307  0.0319  0.0332
             14          PC  0.0345  0.0358  0.0371  0.0384  0.0398  0.0411  0.0425
0.0439  0.0452  0.0466
             15          PC   0.048  0.0494  0.0508  0.0523  0.0538  0.0553  0.0568
0.0583  0.0598  0.0614
             16          PC   0.063  0.0646  0.0662  0.0679  0.0696  0.0712   0.073
0.0747  0.0764  0.0782
             17          PC    0.08  0.0818  0.0836  0.0855  0.0874  0.0892  0.0912
0.0931   0.095   0.097
```

```
18   PC  0.099   0.101   0.103   0.1051  0.1072  0.1093  0.1114  0.1135  0.1156  0.1178
19   PC  0.12    0.1223  0.1246  0.1271  0.1296  0.1323  0.135   0.1379  0.1408  0.1439
20   PC  0.147   0.1502  0.1534  0.1566  0.1598  0.163   0.1663  0.1697  0.1733  0.1771
21   PC  0.181   0.1851  0.1895  0.1941  0.1989  0.204   0.2094  0.2152  0.2214  0.228
22   PC  0.235   0.2427  0.2513  0.2609  0.2715  0.283   0.3068  0.3544  0.4308  0.5679
23   PC  0.663   0.682   0.6986  0.713   0.7252  0.735   0.7434  0.7514  0.7588  0.7656
24   PC  0.772   0.778   0.7836  0.789   0.7942  0.799   0.8036  0.808   0.8122  0.8162
25   PC  0.82    0.8237  0.8273  0.8308  0.8342  0.8376  0.8409  0.8442  0.8474  0.8505
26   PC  0.8535  0.8565  0.8594  0.8622  0.8649  0.8676  0.8702  0.8728  0.8753  0.8777
27   PC  0.88    0.8823  0.8845  0.8868  0.889   0.8912  0.8933  0.8955  0.8976  0.8997
28   PC  0.9018  0.9038  0.9058  0.9078  0.9097  0.9117  0.9136  0.9155  0.9174  0.9192
29   PC  0.921   0.9228  0.9245  0.9263  0.928   0.9297  0.9314  0.933   0.9346  0.9362
30   PC  0.9377  0.9393  0.9408  0.9423  0.9437  0.9452  0.9466  0.948   0.9494  0.9507
31   PC  0.952   0.9533  0.9546  0.9559  0.9572  0.9584  0.9597  0.961   0.9622  0.9635
32   PC  0.9648  0.966   0.9672  0.9685  0.9697  0.9709  0.9722  0.9734  0.9746  0.9758
33   PC  0.977   0.9782  0.9794  0.9806  0.9818  0.9829  0.9841  0.9853  0.9864  0.9876
34   PC  0.9888  0.9899  0.991   0.9922  0.9933  0.9944  0.9956  0.9967  0.9978  0.9989
35   PC  1.0
36   LS  0.0     70.0    0.0
37   UD  1.3

38   KK  2R      CNAME   2C
39   KO  0       0       0.0     0       22
40   RN  2R

41   KK  CELL1
42   KO  0       0       0.0     0       22
43   BA  0.17
44   PB  2.08
45   IN  6       1JAN94  0
     * typeII-24hour
46   PC  0.0     0.001   0.002   0.0031  0.0041  0.0051  0.0062  0.0073  0.0083  0.0094
47   PC  0.0105  0.0116  0.0127  0.0138  0.015   0.0161  0.0173  0.0185  0.0196  0.0208
48   PC  0.022   0.0232  0.0244  0.0256  0.0269  0.0281  0.0294  0.0307  0.0319  0.0332
49   PC  0.0345  0.0358  0.0371  0.0384  0.0398  0.0411  0.0425  0.0439  0.0452  0.0466
```

```
            LINE
ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              50        PC   0.048  0.0494  0.0508  0.0523  0.0538  0.0553  0.0568
0.0583  0.0598  0.0614
              51        PC   0.063  0.0646  0.0662  0.0679  0.0696  0.0712   0.073
0.0747  0.0764  0.0782
              52        PC    0.08  0.0818  0.0836  0.0855  0.0874  0.0892  0.0912
0.0931   0.095   0.097
              53        PC   0.099   0.101   0.103  0.1051  0.1072  0.1093  0.1114
0.1135  0.1156  0.1178
              54        PC    0.12  0.1223  0.1246  0.1271  0.1296  0.1323   0.135
0.1379  0.1408  0.1439
              55        PC   0.147  0.1502  0.1534  0.1566  0.1598   0.163  0.1663
0.1697  0.1733  0.1771
              56        PC   0.181  0.1851  0.1895  0.1941  0.1989   0.204  0.2094
0.2152  0.2214   0.228
              57        PC   0.235  0.2427  0.2513  0.2609  0.2715   0.283  0.3068
0.3544  0.4308  0.5679
              58        PC   0.663   0.682  0.6986   0.713  0.7252   0.735  0.7434
0.7514  0.7588  0.7656
              59        PC   0.772   0.778  0.7836   0.789  0.7942   0.799  0.8036
0.808  0.8122  0.8162
              60        PC    0.82  0.8237  0.8273  0.8308  0.8342  0.8376  0.8409
0.8442  0.8474  0.8505
              61        PC  0.8535  0.8565  0.8594  0.8622  0.8649  0.8676  0.8702
0.8728  0.8753  0.8777
              62        PC    0.88  0.8823  0.8845  0.8868   0.889  0.8912  0.8933
0.8955  0.8976  0.8997
              63        PC  0.9018  0.9038  0.9058  0.9078  0.9097  0.9117  0.9136
0.9155  0.9174  0.9192
              64        PC   0.921  0.9228  0.9245  0.9263   0.928  0.9297  0.9314
0.933  0.9346  0.9362
              65        PC  0.9377  0.9393  0.9408  0.9423  0.9437  0.9452  0.9466
0.948  0.9494  0.9507
              66        PC   0.952  0.9533  0.9546  0.9559  0.9572  0.9584  0.9597
0.961  0.9622  0.9635
              67        PC  0.9648   0.966  0.9672  0.9685  0.9697  0.9709  0.9722
0.9734  0.9746  0.9758
              68        PC   0.977  0.9782  0.9794  0.9806  0.9818  0.9829  0.9841
0.9853  0.9864  0.9876
              69        PC  0.9888  0.9899   0.991  0.9922  0.9933  0.9944  0.9956
0.9967  0.9978  0.9989
              70        PC     1.0
              71        LS     0.0    70.0     0.0
              72        UD     1.0

              73        KK      1R   CNAME      1C
              74        KO       0       0     0.0       0      22
              75        RN      1R
              76        ZZ
```

```
                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE       (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

  NO.       (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

   6         CELL2
                 V
                 V
  38            2R
                 .
                 .
  41             .         CELL1
                 .             V
                 .             V
  73             .            1R

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*****************************************
 *                                       *
*                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*    U.S. ARMY CORPS OF ENGINEERS       *
 *             MAY   1991                *
*    HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.0.1E             *
*          609 SECOND STREET            *
 *                                       *
*        DAVIS, CALIFORNIA 95616        *
 *  RUN DATE          TIME               *
*           (916) 551-1748              *
 *                                       *
*                                       *
 *****************************************
*****************************************


                          HEC-1 Analysis using WMS


   5 IO           OUTPUT CONTROL VARIABLES
                        IPRNT            0  PRINT CONTROL
                        IPLOT            0  PLOT CONTROL
                        QSCAL           0.  HYDROGRAPH PLOT SCALE

     IT           HYDROGRAPH TIME DATA
                         NMIN           15  MINUTES IN COMPUTATION INTERVAL
                        IDATE       1JAN94  STARTING DATE
                        ITIME         0000  STARTING TIME
                           NQ,         150  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE       2JAN94  ENDING DATE
                       NDTIME         1315  ENDING TIME
                        ICENT           19  CENTURY MARK

                    COMPUTATION INTERVAL    0.25 HOURS
                         TOTAL TIME BASE   37.25 HOURS

          ENGLISH UNITS
               DRAINAGE AREA           SQUARE MILES
               PRECIPITATION DEPTH     INCHES
               LENGTH, ELEVATION       FEET
               FLOW                    CUBIC FEET PER SECOND
               STORAGE VOLUME          ACRE-FEET
               SURFACE AREA            ACRES
               TEMPERATURE             DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
*** *** *** *** *** *** *** *** *** *** ***


                 **************
                 *            *
   6 KK          *    CELL2   *
```

```
            *           *
            **************

  7 KO          OUTPUT CONTROL VARIABLES
                     IPRNT          0  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE
                     IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                      IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        150  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT      0.250  TIME INTERVAL IN HOURS


 10 IN          TIME DATA FOR INPUT TIME SERIES
                     JXMIN          6  TIME INTERVAL IN MINUTES
                    JXDATE     1JAN94  STARTING DATE
                    JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

  8 BA          SUBBASIN CHARACTERISTICS
                     TAREA,      0.18  SUBBASIN AREA

                PRECIPITATION DATA

  9 PB               STORM       2.08  BASIN TOTAL PRECIPITATION

 11 PI            INCREMENTAL PRECIPITATION PATTERN
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00
 0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00
 0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00
 0.00      0.01      0.01
                     0.01      0.01      0.01      0.01      0.01      0.01      0.01
 0.01      0.01      0.01
                     0.01      0.01      0.01      0.02      0.02      0.03      0.11
 0.27      0.04      0.03
                     0.02      0.02      0.01      0.01      0.01      0.01      0.01
 0.01      0.01      0.01
                     0.01      0.01      0.01      0.01      0.01      0.01      0.01
 0.01      0.01      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00
 0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00
 0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00

 36 LS          SCS LOSS RATE
                     STRTL       0.86  INITIAL ABSTRACTION
                    CRVNBR      70.00  CURVE NUMBER
                     RTIMP       0.00  PERCENT IMPERVIOUS AREA

 37 UD          SCS DIMENSIONLESS UNITGRAPH
                      TLAG       1.30  LAG

                                                               ***

                                                       UNIT HYDROGRAPH
                                                   28 END-OF-PERIOD ORDINATES
                  5.        16.        32.        51.        61.        62.        56.
 48.       36.     26.
                 20.        15.        11.         8.         6.         5.         4.
 3.         2.      2.
                  1.         1.         1.         1.         0.         0.         0.
 0.

*********************************************************************************************
*******************************************

                                                    HYDROGRAPH AT STATION     CELL2

*********************************************************************************************
*******************************************

                                                               *
       DA MON HRMN  ORD    RAIN    LOSS  EXCESS    COMP Q      *        DA MON HRMN
ORD    RAIN    LOSS  EXCESS     COMP Q
                                                               *
```

	1 JAN 0000	1	0.00	0.00	0.00	0.	*	1 JAN 1845
76	0.01	0.01	0.00	2.				
	1 JAN 0015	2	0.01	0.01	0.00	0.	*	1 JAN 1900
77	0.01	0.01	0.00	2.				
	1 JAN 0030	3	0.01	0.01	0.00	0.	*	1 JAN 1915
78	0.01	0.01	0.00	2.				
	1 JAN 0045	4	0.01	0.01	0.00	0.	*	1 JAN 1930
79	0.01	0.00	0.00	2.				
	1 JAN 0100	5	0.01	0.01	0.00	0.	*	1 JAN 1945
80	0.01	0.00	0.00	2.				
	1 JAN 0115	6	0.01	0.01	0.00	0.	*	1 JAN 2000
81	0.01	0.00	0.00	2.				
	1 JAN 0130	7	0.01	0.01	0.00	0.	*	1 JAN 2015
82	0.01	0.00	0.00	1.				
	1 JAN 0145	8	0.01	0.01	0.00	0.	*	1 JAN 2030
83	0.01	0.00	0.00	1.				
	1 JAN 0200	9	0.01	0.01	0.00	0.	*	1 JAN 2045
84	0.01	0.00	0.00	1.				
	1 JAN 0215	10	0.01	0.01	0.00	0.	*	1 JAN 2100
85	0.01	0.00	0.00	1.				
	1 JAN 0230	11	0.01	0.01	0.00	0.	*	1 JAN 2115
86	0.01	0.00	0.00	1.				
	1 JAN 0245	12	0.01	0.01	0.00	0.	*	1 JAN 2130
87	0.01	0.00	0.00	1.				
	1 JAN 0300	13	0.01	0.01	0.00	0.	*	1 JAN 2145
88	0.01	0.00	0.00	1.				
	1 JAN 0315	14	0.01	0.01	0.00	0.	*	1 JAN 2200
89	0.01	0.00	0.00	1.				
	1 JAN 0330	15	0.01	0.01	0.00	0.	*	1 JAN 2215
90	0.01	0.00	0.00	1.				
	1 JAN 0345	16	0.01	0.01	0.00	0.	*	1 JAN 2230
91	0.01	0.00	0.00	1.				
	1 JAN 0400	17	0.01	0.01	0.00	0.	*	1 JAN 2245
92	0.01	0.00	0.00	1.				
	1 JAN 0415	18	0.01	0.01	0.00	0.	*	1 JAN 2300
93	0.01	0.00	0.00	1.				
	1 JAN 0430	19	0.01	0.01	0.00	0.	*	1 JAN 2315
94	0.01	0.00	0.00	1.				
	1 JAN 0445	20	0.01	0.01	0.00	0.	*	1 JAN 2330
95	0.01	0.00	0.00	1.				
	1 JAN 0500	21	0.01	0.01	0.00	0.	*	1 JAN 2345
96	0.01	0.00	0.00	1.				
	1 JAN 0515	22	0.01	0.01	0.00	0.	*	2 JAN 0000
97	0.01	0.00	0.00	1.				
	1 JAN 0530	23	0.01	0.01	0.00	0.	*	2 JAN 0015
98	0.00	0.00	0.00	1.				
	1 JAN 0545	24	0.01	0.01	0.00	0.	*	2 JAN 0030
99	0.00	0.00	0.00	1.				
	1 JAN 0600	25	0.01	0.01	0.00	0.	*	2 JAN 0045
100	0.00	0.00	0.00	1.				
	1 JAN 0615	26	0.01	0.01	0.00	0.	*	2 JAN 0100
101	0.00	0.00	0.00	1.				
	1 JAN 0630	27	0.01	0.01	0.00	0.	*	2 JAN 0115
102	0.00	0.00	0.00	1.				
	1 JAN 0645	28	0.01	0.01	0.00	0.	*	2 JAN 0130
103	0.00	0.00	0.00	1.				
	1 JAN 0700	29	0.01	0.01	0.00	0.	*	2 JAN 0145
104	0.00	0.00	0.00	0.				
	1 JAN 0715	30	0.01	0.01	0.00	0.	*	2 JAN 0200
105	0.00	0.00	0.00	0.				
	1 JAN 0730	31	0.01	0.01	0.00	0.	*	2 JAN 0215
106	0.00	0.00	0.00	0.				
	1 JAN 0745	32	0.01	0.01	0.00	0.	*	2 JAN 0230
107	0.00	0.00	0.00	0.				
	1 JAN 0800	33	0.01	0.01	0.00	0.	*	2 JAN 0245
108	0.00	0.00	0.00	0.				
	1 JAN 0815	34	0.01	0.01	0.00	0.	*	2 JAN 0300
109	0.00	0.00	0.00	0.				
	1 JAN 0830	35	0.01	0.01	0.00	0.	*	2 JAN 0315
110	0.00	0.00	0.00	0.				
	1 JAN 0845	36	0.01	0.01	0.00	0.	*	2 JAN 0330
111	0.00	0.00	0.00	0.				
	1 JAN 0900	37	0.02	0.02	0.00	0.	*	2 JAN 0345
112	0.00	0.00	0.00	0.				
	1 JAN 0915	38	0.02	0.02	0.00	0.	*	2 JAN 0400
113	0.00	0.00	0.00	0.				
	1 JAN 0930	39	0.02	0.02	0.00	0.	*	2 JAN 0415
114	0.00	0.00	0.00	0.				
	1 JAN 0945	40	0.02	0.02	0.00	0.	*	2 JAN 0430
115	0.00	0.00	0.00	0.				

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          1 JAN 1000   41    0.02    0.02    0.00        0.       *      2 JAN 0445
  116   0.00    0.00    0.00         0.
          1 JAN 1015   42    0.02    0.02    0.00        0.       *      2 JAN 0500
  117   0.00    0.00    0.00         0.
          1 JAN 1030   43    0.03    0.03    0.00        0.       *      2 JAN 0515
  118   0.00    0.00    0.00         0.
          1 JAN 1045   44    0.03    0.03    0.00        0.       *      2 JAN 0530
  119   0.00    0.00    0.00         0.
          1 JAN 1100   45    0.03    0.03    0.00        0.       *      2 JAN 0545
  120   0.00    0.00    0.00         0.
          1 JAN 1115   46    0.04    0.04    0.00        0.       *      2 JAN 0600
  121   0.00    0.00    0.00         0.
          1 JAN 1130   47    0.06    0.06    0.00        0.       *      2 JAN 0615
  122   0.00    0.00    0.00         0.
          1 JAN 1145   48    0.23    0.23    0.00        0.       *      2 JAN 0630
  123   0.00    0.00    0.00         0.
          1 JAN 1200   49    0.56    0.51    0.06        0.       *      2 JAN 0645
  124   0.00    0.00    0.00         0.
          1 JAN 1215   50    0.09    0.07    0.02        1.       *      2 JAN 0700
  125   0.00    0.00    0.00         0.
          1 JAN 1230   51    0.06    0.05    0.01        2.       *      2 JAN 0715
  126   0.00    0.00    0.00         0.
          1 JAN 1245   52    0.04    0.03    0.01        4.       *      2 JAN 0730
  127   0.00    0.00    0.00         0.
          1 JAN 1300   53    0.04    0.03    0.01        5.       *      2 JAN 0745
  128   0.00    0.00    0.00         0.
          1 JAN 1315   54    0.03    0.02    0.01        6.       *      2 JAN 0800
  129   0.00    0.00    0.00         0.
          1 JAN 1330   55    0.03    0.02    0.01        6.       *      2 JAN 0815
  130   0.00    0.00    0.00         0.
          1 JAN 1345   56    0.02    0.02    0.01        6.       *      2 JAN 0830
  131   0.00    0.00    0.00         0.
          1 JAN 1400   57    0.02    0.01    0.01        6.       *      2 JAN 0845
  132   0.00    0.00    0.00         0.
          1 JAN 1415   58    0.02    0.01    0.01        5.       *      2 JAN 0900
  133   0.00    0.00    0.00         0.
          1 JAN 1430   59    0.02    0.01    0.01        5.       *      2 JAN 0915
  134   0.00    0.00    0.00         0.
          1 JAN 1445   60    0.02    0.01    0.01        4.       *      2 JAN 0930
  135   0.00    0.00    0.00         0.
          1 JAN 1500   61    0.02    0.01    0.01        4.       *      2 JAN 0945
  136   0.00    0.00    0.00         0.
          1 JAN 1515   62    0.02    0.01    0.00        4.       *      2 JAN 1000
  137   0.00    0.00    0.00         0.
          1 JAN 1530   63    0.01    0.01    0.00        3.       *      2 JAN 1015
  138   0.00    0.00    0.00         0.
          1 JAN 1545   64    0.01    0.01    0.00        3.       *      2 JAN 1030
  139   0.00    0.00    0.00         0.
          1 JAN 1600   65    0.01    0.01    0.00        3.       *      2 JAN 1045
  140   0.00    0.00    0.00         0.
          1 JAN 1615   66    0.01    0.01    0.00        3.       *      2 JAN 1100
  141   0.00    0.00    0.00         0.
          1 JAN 1630   67    0.01    0.01    0.00        3.       *      2 JAN 1115
  142   0.00    0.00    0.00         0.
          1 JAN 1645   68    0.01    0.01    0.00        2.       *      2 JAN 1130
  143   0.00    0.00    0.00         0.
          1 JAN 1700   69    0.01    0.01    0.00        2.       *      2 JAN 1145
  144   0.00    0.00    0.00         0.
          1 JAN 1715   70    0.01    0.01    0.00        2.       *      2 JAN 1200
  145   0.00    0.00    0.00         0.
          1 JAN 1730   71    0.01    0.01    0.00        2.       *      2 JAN 1215
  146   0.00    0.00    0.00         0.
          1 JAN 1745   72    0.01    0.01    0.00        2.       *      2 JAN 1230
  147   0.00    0.00    0.00         0.
          1 JAN 1800   73    0.01    0.01    0.00        2.       *      2 JAN 1245
  148   0.00    0.00    0.00         0.
          1 JAN 1815   74    0.01    0.01    0.00        2.       *      2 JAN 1300
  149   0.00    0.00    0.00         0.
          1 JAN 1830   75    0.01    0.01    0.00        2.       *      2 JAN 1315
  150   0.00    0.00    0.00         0.
                                                                  *

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      TOTAL RAINFALL =     2.08, TOTAL LOSS =     1.81, TOTAL EXCESS =     0.27

    PEAK FLOW       TIME                              MAXIMUM AVERAGE FLOW
                                           6-HR          24-HR          72-HR        37.25-HR
+    (CFS)          (HR)
                                (CFS)
```

```
+        6.      13.50                      4.             1.            1.              1.
                          (INCHES)      0.186          0.271         0.271           0.271
                           (AC-FT)          2.             3.            3.              3.

                           CUMULATIVE AREA =      0.18 SQ MI


 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
*** *** *** *** *** *** *** *** *** *** ***


              **************
              *            *
   38 KK      *     2R     *        CNAME       2C
              *            *
              **************

   39 KO            OUTPUT CONTROL VARIABLES
                          IPRNT           0  PRINT CONTROL
                          IPLOT           0  PLOT CONTROL
                          QSCAL          0.  HYDROGRAPH PLOT SCALE
                          IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                           IOUT          22  SAVE HYDROGRAPH ON THIS UNIT
                          ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                          ISAV2         150  LAST ORDINATE PUNCHED OR SAVED
                         TIMINT       0.250  TIME INTERVAL IN HOURS

                  HYDROGRAPH ROUTING DATA

   40 RN            NO ROUTING

                                                                          ***

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                                                     HYDROGRAPH AT STATION        2R

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*******************************************
                                        *                               *
*
   DA MON HRMN   ORD       FLOW         *  DA MON HRMN   ORD       FLOW *  DA MON HRMN   ORD
FLOW    *  DA MON HRMN   ORD            FLOW
                                        *                               *
*
    1 JAN 0000     1          0.        *   1 JAN 0930    39         0. *   1 JAN 1900    77
2.    *    2 JAN 0430   115             0.
    1 JAN 0015     2          0.        *   1 JAN 0945    40         0. *   1 JAN 1915    78
2.    *    2 JAN 0445   116             0.
    1 JAN 0030     3          0.        *   1 JAN 1000    41         0. *   1 JAN 1930    79
2.    *    2 JAN 0500   117             0.
    1 JAN 0045     4          0.        *   1 JAN 1015    42         0. *   1 JAN 1945    80
2.    *    2 JAN 0515   118             0.
    1 JAN 0100     5          0.        *   1 JAN 1030    43         0. *   1 JAN 2000    81
2.    *    2 JAN 0530   119             0.
    1 JAN 0115     6          0.        *   1 JAN 1045    44         0. *   1 JAN 2015    82
1.    *    2 JAN 0545   120             0.
    1 JAN 0130     7          0.        *   1 JAN 1100    45         0. *   1 JAN 2030    83
1.    *    2 JAN 0600   121             0.
    1 JAN 0145     8          0.        *   1 JAN 1115    46         0. *   1 JAN 2045    84
1.    *    2 JAN 0615   122             0.
    1 JAN 0200     9          0.        *   1 JAN 1130    47         0. *   1 JAN 2100    85
1.    *    2 JAN 0630   123             0.
    1 JAN 0215    10          0.        *   1 JAN 1145    48         0. *   1 JAN 2115    86
1.    *    2 JAN 0645   124             0.
    1 JAN 0230    11          0.        *   1 JAN 1200    49         0. *   1 JAN 2130    87
1.    *    2 JAN 0700   125             0.
    1 JAN 0245    12          0.        *   1 JAN 1215    50         1. *   1 JAN 2145    88
1.    *    2 JAN 0715   126             0.
    1 JAN 0300    13          0.        *   1 JAN 1230    51         2. *   1 JAN 2200    89
1.    *    2 JAN 0730   127             0.
    1 JAN 0315    14          0.        *   1 JAN 1245    52         4. *   1 JAN 2215    90
1.    *    2 JAN 0745   128             0.
    1 JAN 0330    15          0.        *   1 JAN 1300    53         5. *   1 JAN 2230    91
1.    *    2 JAN 0800   129             0.
```

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          1 JAN 0345    16           0.    *    1 JAN 1315    54          6.    *    1 JAN 2245    92
  1.      *     2 JAN 0815   130             0.
          1 JAN 0400    17           0.    *    1 JAN 1330    55          6.    *    1 JAN 2300    93
  1.      *     2 JAN 0830   131             0.
          1 JAN 0415    18           0.    *    1 JAN 1345    56          6.    *    1 JAN 2315    94
  1.      *     2 JAN 0845   132             0.
          1 JAN 0430    19           0.    *    1 JAN 1400    57          6.    *    1 JAN 2330    95
  1.      *     2 JAN 0900   133             0.
          1 JAN 0445    20           0.    *    1 JAN 1415    58          5.    *    1 JAN 2345    96
  1.      *     2 JAN 0915   134             0.
          1 JAN 0500    21           0.    *    1 JAN 1430    59          5.    *    2 JAN 0000    97
  1.      *     2 JAN 0930   135             0.
          1 JAN 0515    22           0.    *    1 JAN 1445    60          4.    *    2 JAN 0015    98
  1.      *     2 JAN 0945   136             0.
          1 JAN 0530    23           0.    *    1 JAN 1500    61          4.    *    2 JAN 0030    99
  1.      *     2 JAN 1000   137             0.
          1 JAN 0545    24           0.    *    1 JAN 1515    62          4.    *    2 JAN 0045   100
  1.      *     2 JAN 1015   138             0.
          1 JAN 0600    25           0.    *    1 JAN 1530    63          3.    *    2 JAN 0100   101
  1.      *     2 JAN 1030   139             0.
          1 JAN 0615    26           0.    *    1 JAN 1545    64          3.    *    2 JAN 0115   102
  1.      *     2 JAN 1045   140             0.
          1 JAN 0630    27           0.    *    1 JAN 1600    65          3.    *    2 JAN 0130   103
  1.      *     2 JAN 1100   141             0.
          1 JAN 0645    28           0.    *    1 JAN 1615    66          3.    *    2 JAN 0145   104
  0.      *     2 JAN 1115   142             0.
          1 JAN 0700    29           0.    *    1 JAN 1630    67          3.    *    2 JAN 0200   105
  0.      *     2 JAN 1130   143             0.
          1 JAN 0715    30           0.    *    1 JAN 1645    68          2.    *    2 JAN 0215   106
  0.      *     2 JAN 1145   144             0.
          1 JAN 0730    31           0.    *    1 JAN 1700    69          2.    *    2 JAN 0230   107
  0.      *     2 JAN 1200   145             0.
          1 JAN 0745    32           0.    *    1 JAN 1715    70          2.    *    2 JAN 0245   108
  0.      *     2 JAN 1215   146             0.
          1 JAN 0800    33           0.    *    1 JAN 1730    71          2.    *    2 JAN 0300   109
  0.      *     2 JAN 1230   147             0.
          1 JAN 0815    34           0.    *    1 JAN 1745    72          2.    *    2 JAN 0315   110
  0.      *     2 JAN 1245   148             0.
          1 JAN 0830    35           0.    *    1 JAN 1800    73          2.    *    2 JAN 0330   111
  0.      *     2 JAN 1300   149             0.
          1 JAN 0845    36           0.    *    1 JAN 1815    74          2.    *    2 JAN 0345   112
  0.      *     2 JAN 1315   150             0.
          1 JAN 0900    37           0.    *    1 JAN 1830    75          2.    *    2 JAN 0400   113
  0.      *
          1 JAN 0915    38           0.    *    1 JAN 1845    76          2.    *    2 JAN 0415   114
  0.      *
                                           *                                  *
  *

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    PEAK FLOW      TIME                                    MAXIMUM AVERAGE FLOW
                                               6-HR        24-HR        72-HR        37.25-HR
 +     (CFS)       (HR)
                                  (CFS)
 +         6.      13.50                          4.           1.           1.             1.
                                (INCHES)      0.186        0.271        0.271          0.271
                                 (AC-FT)         2.           3.           3.             3.

                                CUMULATIVE AREA =       0.18 SQ MI


 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
 *** *** *** *** *** *** *** *** *** *** ***


                  **************
                  *            *
    41 KK         *   CELL1    *
                  *            *
                  **************

    42 KO            OUTPUT CONTROL VARIABLES
                            IPRNT            0   PRINT CONTROL
                            IPLOT            0   PLOT CONTROL
                            QSCAL           0.   HYDROGRAPH PLOT SCALE
                            IPNCH            0   PUNCH COMPUTED HYDROGRAPH
                             IOUT           22   SAVE HYDROGRAPH ON THIS UNIT
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                         ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                         ISAV2        150  LAST ORDINATE PUNCHED OR SAVED
                        TIMINT      0.250  TIME INTERVAL IN HOURS

   45 IN             TIME DATA FOR INPUT TIME SERIES
                        JXMIN           6  TIME INTERVAL IN MINUTES
                        JXDATE     1JAN94  STARTING DATE
                        JXTIME          0  STARTING TIME

                   SUBBASIN RUNOFF DATA

   43 BA             SUBBASIN CHARACTERISTICS
                         TAREA,      0.17  SUBBASIN AREA

                     PRECIPITATION DATA

   44 PB                 STORM       2.08  BASIN TOTAL PRECIPITATION

   46 PI               INCREMENTAL PRECIPITATION PATTERN
                         0.00       0.00       0.00       0.00       0.00       0.00       0.00
  0.00       0.00      0.00
                         0.00       0.00       0.00       0.00       0.00       0.00       0.00
  0.00       0.00      0.00
                         0.00       0.00       0.00       0.00       0.00       0.00       0.00
  0.00       0.01      0.01
                         0.01       0.01       0.01       0.01       0.01       0.01       0.01
  0.01       0.01      0.01
                         0.01       0.01       0.01       0.02       0.02       0.03       0.11
  0.27       0.04      0.03
                         0.02       0.02       0.01       0.01       0.01       0.01       0.01
  0.01       0.01      0.01
                         0.01       0.01       0.01       0.01       0.01       0.01       0.01
  0.01       0.01      0.00
                         0.00       0.00       0.00       0.00       0.00       0.00       0.00
  0.00       0.00      0.00
                         0.00       0.00       0.00       0.00       0.00       0.00       0.00
  0.00       0.00      0.00
                         0.00       0.00       0.00       0.00       0.00       0.00

   71 LS             SCS LOSS RATE
                        STRTL        0.86  INITIAL ABSTRACTION
                        CRVNBR      70.00  CURVE NUMBER
                        RTIMP        0.00  PERCENT IMPERVIOUS AREA

   72 UD             SCS DIMENSIONLESS UNITGRAPH
                          TLAG       1.00  LAG

                                                                       ***

                                                                  UNIT HYDROGRAPH
                                                              22 END-OF-PERIOD ORDINATES
                       9.         28.        56.        72.        72.        61.        45.
 30.        20.          15.
                      10.          7.         5.         3.         2.         2.         1.
 1.          1.          0.
                       0.          0.

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                                                          HYDROGRAPH AT STATION    CELL1

*********************************************************************************************
*******************************************
                                                                       *
        DA MON HRMN  ORD   RAIN   LOSS  EXCESS      COMP Q             *        DA MON HRMN
ORD    RAIN    LOSS   EXCESS      COMP Q
                                                                       *
          1 JAN 0000   1   0.00   0.00   0.00          0.              *         1 JAN 1845
76     0.01    0.01   0.00        2.
          1 JAN 0015   2   0.01   0.01   0.00          0.              *         1 JAN 1900
77     0.01    0.01   0.00        2.
          1 JAN 0030   3   0.01   0.01   0.00          0.              *         1 JAN 1915
78     0.01    0.01   0.00        1.
          1 JAN 0045   4   0.01   0.01   0.00          0.              *         1 JAN 1930
79     0.01    0.00   0.00        1.
          1 JAN 0100   5   0.01   0.01   0.00          0.              *         1 JAN 1945
80     0.01    0.00   0.00        1.
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        1 JAN 0115   6     0.01    0.01    0.00       0.      *     1 JAN 2000
 81   0.01    0.00   0.00          1.
        1 JAN 0130   7     0.01    0.01    0.00       0.      *     1 JAN 2015
 82   0.01    0.00   0.00          1.
        1 JAN 0145   8     0.01    0.01    0.00       0.      *     1 JAN 2030
 83   0.01    0.00   0.00          1.
        1 JAN 0200   9     0.01    0.01    0.00       0.      *     1 JAN 2045
 84   0.01    0.00   0.00          1.
        1 JAN 0215   10    0.01    0.01    0.00       0.      *     1 JAN 2100
 85   0.01    0.00   0.00          1.
        1 JAN 0230   11    0.01    0.01    0.00       0.      *     1 JAN 2115
 86   0.01    0.00   0.00          1.
        1 JAN 0245   12    0.01    0.01    0.00       0.      *     1 JAN 2130
 87   0.01    0.00   0.00          1.
        1 JAN 0300   13    0.01    0.01    0.00       0.      *     1 JAN 2145
 88   0.01    0.00   0.00          1.
        1 JAN 0315   14    0.01    0.01    0.00       0.      *     1 JAN 2200
 89   0.01    0.00   0.00          1.
        1 JAN 0330   15    0.01    0.01    0.00       0.      *     1 JAN 2215
 90   0.01    0.00   0.00          1.
        1 JAN 0345   16    0.01    0.01    0.00       0.      *     1 JAN 2230
 91   0.01    0.00   0.00          1.
        1 JAN 0400   17    0.01    0.01    0.00       0.      *     1 JAN 2245
 92   0.01    0.00   0.00          1.
        1 JAN 0415   18    0.01    0.01    0.00       0.      *     1 JAN 2300
 93   0.01    0.00   0.00          1.
        1 JAN 0430   19    0.01    0.01    0.00       0.      *     1 JAN 2315
 94   0.01    0.00   0.00          1.
        1 JAN 0445   20    0.01    0.01    0.00       0.      *     1 JAN 2330
 95   0.01    0.00   0.00          1.
        1 JAN 0500   21    0.01    0.01    0.00       0.      *     1 JAN 2345
 96   0.01    0.00   0.00          1.
        1 JAN 0515   22    0.01    0.01    0.00       0.      *     2 JAN 0000
 97   0.01    0.00   0.00          1.
        1 JAN 0530   23    0.01    0.01    0.00       0.      *     2 JAN 0015
 98   0.00    0.00   0.00          1.
        1 JAN 0545   24    0.01    0.01    0.00       0.      *     2 JAN 0030
 99   0.00    0.00   0.00          1.
        1 JAN 0600   25    0.01    0.01    0.00       0.      *     2 JAN 0045
100   0.00    0.00   0.00          1.
        1 JAN 0615   26    0.01    0.01    0.00       0.      *     2 JAN 0100
101   0.00    0.00   0.00          1.
        1 JAN 0630   27    0.01    0.01    0.00       0.      *     2 JAN 0115
102   0.00    0.00   0.00          0.
        1 JAN 0645   28    0.01    0.01    0.00       0.      *     2 JAN 0130
103   0.00    0.00   0.00          0.
        1 JAN 0700   29    0.01    0.01    0.00       0.      *     2 JAN 0145
104   0.00    0.00   0.00          0.
        1 JAN 0715   30    0.01    0.01    0.00       0.      *     2 JAN 0200
105   0.00    0.00   0.00          0.
        1 JAN 0730   31    0.01    0.01    0.00       0.      *     2 JAN 0215
106   0.00    0.00   0.00          0.
        1 JAN 0745   32    0.01    0.01    0.00       0.      *     2 JAN 0230
107   0.00    0.00   0.00          0.
        1 JAN 0800   33    0.01    0.01    0.00       0.      *     2 JAN 0245
108   0.00    0.00   0.00          0.
        1 JAN 0815   34    0.01    0.01    0.00       0.      *     2 JAN 0300
109   0.00    0.00   0.00          0.
        1 JAN 0830   35    0.01    0.01    0.00       0.      *     2 JAN 0315
110   0.00    0.00   0.00          0.
        1 JAN 0845   36    0.01    0.01    0.00       0.      *     2 JAN 0330
111   0.00    0.00   0.00          0.
        1 JAN 0900   37    0.02    0.02    0.00       0.      *     2 JAN 0345
112   0.00    0.00   0.00          0.
        1 JAN 0915   38    0.02    0.02    0.00       0.      *     2 JAN 0400
113   0.00    0.00   0.00          0.
        1 JAN 0930   39    0.02    0.02    0.00       0.      *     2 JAN 0415
114   0.00    0.00   0.00          0.
        1 JAN 0945   40    0.02    0.02    0.00       0.      *     2 JAN 0430
115   0.00    0.00   0.00          0.
        1 JAN 1000   41    0.02    0.02    0.00       0.      *     2 JAN 0445
116   0.00    0.00   0.00          0.
        1 JAN 1015   42    0.02    0.02    0.00       0.      *     2 JAN 0500
117   0.00    0.00   0.00          0.
        1 JAN 1030   43    0.03    0.03    0.00       0.      *     2 JAN 0515
118   0.00    0.00   0.00          0.
        1 JAN 1045   44    0.03    0.03    0.00       0.      *     2 JAN 0530
119   0.00    0.00   0.00          0.
        1 JAN 1100   45    0.03    0.03    0.00       0.      *     2 JAN 0545
120   0.00    0.00   0.00          0.
```

1 JAN 1115	46	0.04	0.04	0.00	0.	*	2 JAN 0600	121	0.00	0.00	0.00	0.
1 JAN 1130	47	0.06	0.06	0.00	0.	*	2 JAN 0615	122	0.00	0.00	0.00	0.
1 JAN 1145	48	0.23	0.23	0.00	0.	*	2 JAN 0630	123	0.00	0.00	0.00	0.
1 JAN 1200	49	0.56	0.51	0.06	0.	*	2 JAN 0645	124	0.00	0.00	0.00	0.
1 JAN 1215	50	0.09	0.07	0.02	2.	*	2 JAN 0700	125	0.00	0.00	0.00	0.
1 JAN 1230	51	0.06	0.05	0.01	4.	*	2 JAN 0715	126	0.00	0.00	0.00	0.
1 JAN 1245	52	0.04	0.03	0.01	6.	*	2 JAN 0730	127	0.00	0.00	0.00	0.
1 JAN 1300	53	0.04	0.03	0.01	7.	*	2 JAN 0745	128	0.00	0.00	0.00	0.
1 JAN 1315	54	0.03	0.02	0.01	7.	*	2 JAN 0800	129	0.00	0.00	0.00	0.
1 JAN 1330	55	0.03	0.02	0.01	6.	*	2 JAN 0815	130	0.00	0.00	0.00	0.
1 JAN 1345	56	0.02	0.02	0.01	6.	*	2 JAN 0830	131	0.00	0.00	0.00	0.
1 JAN 1400	57	0.02	0.01	0.01	5.	*	2 JAN 0845	132	0.00	0.00	0.00	0.
1 JAN 1415	58	0.02	0.01	0.01	4.	*	2 JAN 0900	133	0.00	0.00	0.00	0.
1 JAN 1430	59	0.02	0.01	0.01	4.	*	2 JAN 0915	134	0.00	0.00	0.00	0.
1 JAN 1445	60	0.02	0.01	0.01	4.	*	2 JAN 0930	135	0.00	0.00	0.00	0.
1 JAN 1500	61	0.02	0.01	0.01	3.	*	2 JAN 0945	136	0.00	0.00	0.00	0.
1 JAN 1515	62	0.02	0.01	0.00	3.	*	2 JAN 1000	137	0.00	0.00	0.00	0.
1 JAN 1530	63	0.01	0.01	0.00	3.	*	2 JAN 1015	138	0.00	0.00	0.00	0.
1 JAN 1545	64	0.01	0.01	0.00	3.	*	2 JAN 1030	139	0.00	0.00	0.00	0.
1 JAN 1600	65	0.01	0.01	0.00	2.	*	2 JAN 1045	140	0.00	0.00	0.00	0.
1 JAN 1615	66	0.01	0.01	0.00	2.	*	2 JAN 1100	141	0.00	0.00	0.00	0.
1 JAN 1630	67	0.01	0.01	0.00	2.	*	2 JAN 1115	142	0.00	0.00	0.00	0.
1 JAN 1645	68	0.01	0.01	0.00	2.	*	2 JAN 1130	143	0.00	0.00	0.00	0.
1 JAN 1700	69	0.01	0.01	0.00	2.	*	2 JAN 1145	144	0.00	0.00	0.00	0.
1 JAN 1715	70	0.01	0.01	0.00	2.	*	2 JAN 1200	145	0.00	0.00	0.00	0.
1 JAN 1730	71	0.01	0.01	0.00	2.	*	2 JAN 1215	146	0.00	0.00	0.00	0.
1 JAN 1745	72	0.01	0.01	0.00	2.	*	2 JAN 1230	147	0.00	0.00	0.00	0.
1 JAN 1800	73	0.01	0.01	0.00	2.	*	2 JAN 1245	148	0.00	0.00	0.00	0.
1 JAN 1815	74	0.01	0.01	0.00	2.	*	2 JAN 1300	149	0.00	0.00	0.00	0.
1 JAN 1830	75	0.01	0.01	0.00	2.	*	2 JAN 1315	150	0.00	0.00	0.00	0.
						*						

****

TOTAL RAINFALL = 2.08, TOTAL LOSS = 1.81, TOTAL EXCESS = 0.27

	PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
				6-HR	24-HR	72-HR	37.25-HR
+	(CFS)	(HR)					
			(CFS)				
+	7.	13.25		3.	1.	1.	1.
			(INCHES)	0.191	0.271	0.271	0.271
			(AC-FT)	2.	2.	2.	2.

CUMULATIVE AREA = 0.17 SQ MI

```
             **************
             *            *
73 KK        *     1R     *        CNAME      1C
             *            *
             **************

74 KO              OUTPUT CONTROL VARIABLES
                         IPRNT          0  PRINT CONTROL
                         IPLOT          0  PLOT CONTROL
                         QSCAL          0. HYDROGRAPH PLOT SCALE
                         IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                          IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                         ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                         ISAV2        150  LAST ORDINATE PUNCHED OR SAVED
                        TIMINT      0.250  TIME INTERVAL IN HOURS

                 HYDROGRAPH ROUTING DATA

75 RN              NO ROUTING
```

HYDROGRAPH AT STATION 1R

DA MON HRMN	ORD	FLOW	DA MON HRMN	ORD	FLOW	DA MON HRMN	ORD	FLOW	DA MON HRMN	ORD	FLOW
1 JAN 0000	1	0.	1 JAN 0930	39	0.	1 JAN 1900	77	2.	2 JAN 0430	115	0.
1 JAN 0015	2	0.	1 JAN 0945	40	0.	1 JAN 1915	78	1.	2 JAN 0445	116	0.
1 JAN 0030	3	0.	1 JAN 1000	41	0.	1 JAN 1930	79	1.	2 JAN 0500	117	0.
1 JAN 0045	4	0.	1 JAN 1015	42	0.	1 JAN 1945	80	1.	2 JAN 0515	118	0.
1 JAN 0100	5	0.	1 JAN 1030	43	0.	1 JAN 2000	81	1.	2 JAN 0530	119	0.
1 JAN 0115	6	0.	1 JAN 1045	44	0.	1 JAN 2015	82	1.	2 JAN 0545	120	0.
1 JAN 0130	7	0.	1 JAN 1100	45	0.	1 JAN 2030	83	1.	2 JAN 0600	121	0.
1 JAN 0145	8	0.	1 JAN 1115	46	0.	1 JAN 2045	84	1.	2 JAN 0615	122	0.
1 JAN 0200	9	0.	1 JAN 1130	47	0.	1 JAN 2100	85	1.	2 JAN 0630	123	0.
1 JAN 0215	10	0.	1 JAN 1145	48	0.	1 JAN 2115	86	1.	2 JAN 0645	124	0.
1 JAN 0230	11	0.	1 JAN 1200	49	0.	1 JAN 2130	87	1.	2 JAN 0700	125	0.
1 JAN 0245	12	0.	1 JAN 1215	50	2.	1 JAN 2145	88	1.	2 JAN 0715	126	0.
1 JAN 0300	13	0.	1 JAN 1230	51	4.	1 JAN 2200	89	1.	2 JAN 0730	127	0.
1 JAN 0315	14	0.	1 JAN 1245	52	6.	1 JAN 2215	90	1.	2 JAN 0745	128	0.
1 JAN 0330	15	0.	1 JAN 1300	53	7.	1 JAN 2230	91	1.	2 JAN 0800	129	0.
1 JAN 0345	16	0.	1 JAN 1315	54	7.	1 JAN 2245	92	1.	2 JAN 0815	130	0.
1 JAN 0400	17	0.	1 JAN 1330	55	6.	1 JAN 2300	93	1.	2 JAN 0830	131	0.
1 JAN 0415	18	0.	1 JAN 1345	56	6.	1 JAN 2315	94	1.	2 JAN 0845	132	0.
1 JAN 0430	19	0.	1 JAN 1400	57	5.	1 JAN 2330	95	1.	2 JAN 0900	133	0.

```
       1 JAN 0445   20        0.   *   1 JAN 1415   58       4.   *    1 JAN 2345   96
 1.    *   2 JAN 0915   134        0.
       1 JAN 0500   21        0.   *   1 JAN 1430   59       4.   *    2 JAN 0000   97
 1.    *   2 JAN 0930   135        0.
       1 JAN 0515   22        0.   *   1 JAN 1445   60       4.   *    2 JAN 0015   98
 1.    *   2 JAN 0945   136        0.
       1 JAN 0530   23        0.   *   1 JAN 1500   61       3.   *    2 JAN 0030   99
 1.    *   2 JAN 1000   137        0.
       1 JAN 0545   24        0.   *   1 JAN 1515   62       3.   *    2 JAN 0045  100
 1.    *   2 JAN 1015   138        0.
       1 JAN 0600   25        0.   *   1 JAN 1530   63       3.   *    2 JAN 0100  101
 1.    *   2 JAN 1030   139        0.
       1 JAN 0615   26        0.   *   1 JAN 1545   64       3.   *    2 JAN 0115  102
 0.    *   2 JAN 1045   140        0.
       1 JAN 0630   27        0.   *   1 JAN 1600   65       2.   *    2 JAN 0130  103
 0.    *   2 JAN 1100   141        0.
       1 JAN 0645   28        0.   *   1 JAN 1615   66       2.   *    2 JAN 0145  104
 0.    *   2 JAN 1115   142        0.
       1 JAN 0700   29        0.   *   1 JAN 1630   67       2.   *    2 JAN 0200  105
 0.    *   2 JAN 1130   143        0.
       1 JAN 0715   30        0.   *   1 JAN 1645   68       2.   *    2 JAN 0215  106
 0.    *   2 JAN 1145   144        0.
       1 JAN 0730   31        0.   *   1 JAN 1700   69       2.   *    2 JAN 0230  107
 0.    *   2 JAN 1200   145        0.
       1 JAN 0745   32        0.   *   1 JAN 1715   70       2.   *    2 JAN 0245  108
 0.    *   2 JAN 1215   146        0.
       1 JAN 0800   33        0.   *   1 JAN 1730   71       2.   *    2 JAN 0300  109
 0.    *   2 JAN 1230   147        0.
       1 JAN 0815   34        0.   *   1 JAN 1745   72       2.   *    2 JAN 0315  110
 0.    *   2 JAN 1245   148        0.
       1 JAN 0830   35        0.   *   1 JAN 1800   73       2.   *    2 JAN 0330  111
 0.    *   2 JAN 1300   149        0.
       1 JAN 0845   36        0.   *   1 JAN 1815   74       2.   *    2 JAN 0345  112
 0.    *   2 JAN 1315   150        0.
       1 JAN 0900   37        0.   *   1 JAN 1830   75       2.   *    2 JAN 0400  113
 0.    *
       1 JAN 0915   38        0.   *   1 JAN 1845   76       2.   *    2 JAN 0415  114
 0.    *
                                   *                                *
 *

*****************************************************************************************************
*******************************************

   PEAK FLOW     TIME                              MAXIMUM AVERAGE FLOW
                                           6-HR        24-HR        72-HR        37.25-HR
 +    (CFS)      (HR)
                               (CFS)
 +       7.      13.25                       3.           1.           1.            1.
                              (INCHES)   0.191        0.271        0.271         0.271
                               (AC-FT)      2.           2.           2.            2.

                            CUMULATIVE AREA =     0.17 SQ MI
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+ HYDROGRAPH AT	CELL2	6.	13.50	4.	1.	1.	0.18		
+ ROUTED TO	2R	6.	13.50	4.	1.	1.	0.18		
+ HYDROGRAPH AT	CELL1	7.	13.25	3.	1.	1.	0.17		
+ ROUTED TO	1R	7.	13.25	3.	1.	1.	0.17		

*** NORMAL END OF HEC-1 ***

peak discharge (cfs) for largest tributary area in each repective cell.

APPENDIX 5

GROUNDWATER MODEL (HANSON ALLEN & LUCE)

APPENDIX 5.1
Groundwater Model

PROBLEM: CREATE A GW. MODEL OF THE WASATCH REGIONAL LANDFILL TO DETERMINE MAXIMUM POTENTIAL GW. ELEVATIONS. UNDER THE PROPOSED FACILITY.

DATA:
- Groundwater Observations from borings at facility by Kleinfelder in 2003 (SEE SHEET 17)
- Tech Pub. No 42 (Stephens, 1974)
- Precip. data from the Desert Research Institute's Western Regional Climate Center website (www.wrcc.dri.edu).
- USGS 7½ minute topographic quadrangles:
  - Craner Peak
  - Badger Island NW
  - Delle
  - Poverty Point

TABLE OF CONTENTS

ATTACHED - MAP SHOWING MODEL COORDINATE SYSTEM

STUDY AREA

The study area includes the proposed Landfill site located in Sections 33 & 34, Township 2 North, Range 8 West, SLB&M and " " 3 & 4, " 1 ", " 8 ", " west of the Great Salt Lake in Tooele County.
The facility (entire) is located west of the railroad and east of the foot of the Lakeside Mountains.

UTM Zone 12 meters (NAD 83) x = 35[illegible] y = 4,527,221 (approximately)

MODEL DISCRETIZATION

In order to define the MODFLOW MODEL, a coordinate system was established running parallel with section lines, with the northeast corner of Section 28, T 2 N., R. 8 W., SLB&M being coincident with point x = 5,000′ y = 23,000′ in the coordinate system. The model grid consists of square cells with 500 ft per side. There are 46 rows and 74 columns. The west edge of Column 1 coincides with the coordinate x = 0′ and the north edge of row 1 coincides with y = 23,000′.
The coordinate system is shown on the attached (folded) map. North & South boundaries of the model were chosen at least 1 mile north & South of the facility to avoid boundary effects on the target area to be modeled. Due to limited data, the area is modeled as 1 single layer.

BOUNDARY CONDITIONS

The western boundary is modeled as a Specified flux boundary using positive flowrate (injection) wells to simulate recharge from the bedrock and mountain Streams of the Lakeside Mountains. The eastern boundary is modeled as a specified head boundary simulating the constant elevation of the Great Salt Lake. Under existing conditions with the lake level @ elev ≈ 4195′, the lake boundary is at x ≈ 37,000′. Under projected future high lake level conditions (elev [illegible]) the lake boundary is at about x = 16,000′.
The northern & southern model boundaries are modeled as no flow boundaries simulating the west to east flow of groundwater as indicated in Tech. Pub. No. 42 (Stephens, 1974)
(Boundaries [illegible] groundwater [illegible])

The western boundary of active cells in the model corresponds to where the edge of the [illegible] fill [illegible] bedrock outcropping of the Lakeside Mtns.

HANSEN ALLEN & LUCE inc
ENGINEERS

PROJECT Wasatch Regional Landfill Permit
FEATURE Modflow Model - GW Simulations
PROJECT NO 113.30.100
COMPUTED [illegible]
CHECKED [illegible]
DATE 9/7/04

MODEL INPUT

Layer Elevations

The top elevation of the model was determined using the topographic contours of the USGS 7½-minute quads. The bottom elevation ranges from 100 ft below the top elevations on the west to 400 ft below the top elevations on the east. The thickness of the unconsolidated valley fill is certainly greater than 400 feet on the east, but layer properties were modeled using hydraulic conductivity. Therefore, since the bottom elevation is well below the lake level, and hydraulic conductivity is used instead of transmissivity, the bottom elevation shouldn't have a significant impact on model results.

Great Salt Lake Elevations

Current and historical maximum GSL elevations were obtained from the USGS website:

ut.water.usgs.gov/gslelevgraphs/elevations.html

Current elevation = 4195 feet

Max elevation (1984-85) = 4212 ft.

(SEE SHEET 4)

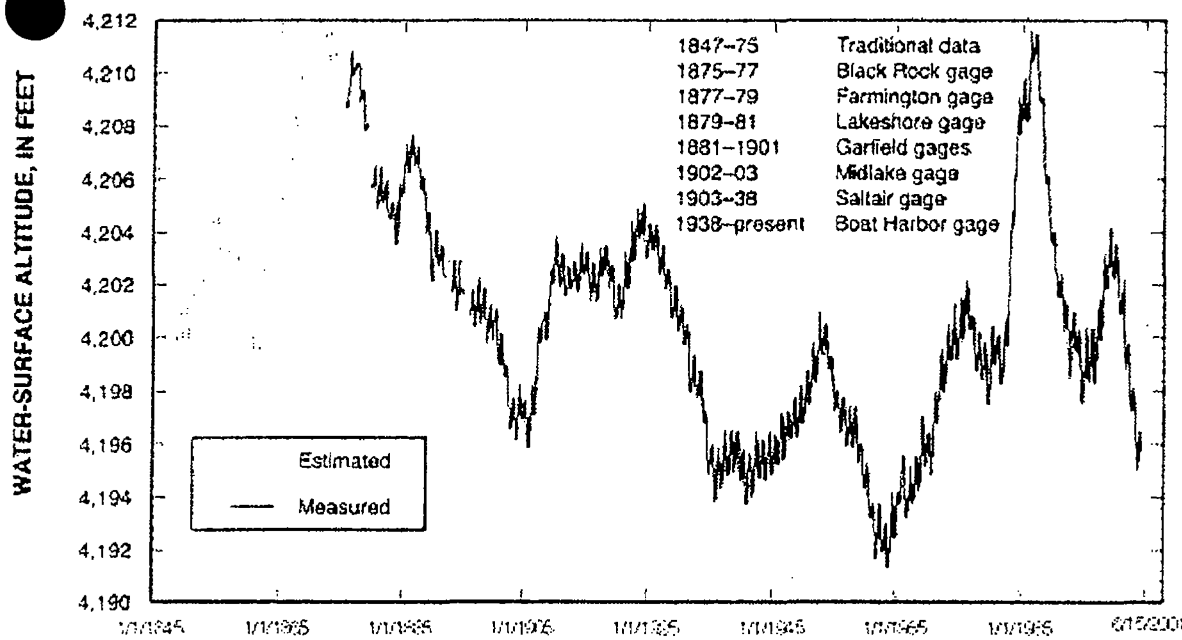
Evapotranspiration

Evapotranspiration was assumed to occur east of the facility. The ET elevation (elevation @ max ET rate) was assumed to be the ground surface. The extinction depth was assumed to be 5 feet (no ET below this). The max ET rate was obtained from the average annual evapotranspiration for cell closure conditions presented in the HELP Model results summary from the September 2004 HAL calculations titled "HELP Model Input Summary."

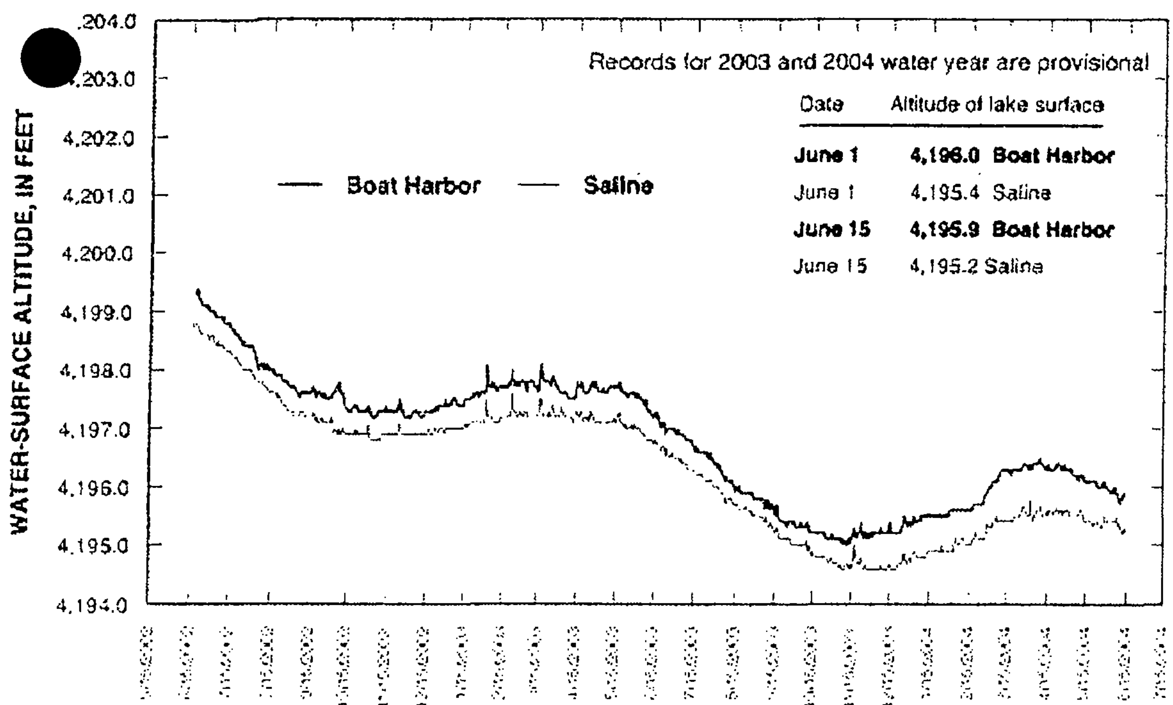
Max ET rate ≈ 12 in/yr on average
= 0.0027 ft/day

USGS
for a changing world

4/17



Fluctuation in water-surface altitude of Gilbert Bay (south part), Great Salt Lake, 1847 to present



Fluctuation in water-surface altitude of both parts of Great Salt Lake during last 2 years

ALLEN & LUCE inc ENGINEERS	PROJECT: Wasatch Regional Landfill Permit	COMPUTED: [illegible]
	FEATURE: Modflow Model - GW Simulations	CHECKED: GMA
	PROJECT NO: 113.30.100	DATE: 8/25/04

Recharge Estimates:

RECHARGE ZONES:

Divide Recharge into 3 zones & assume all recharge is from Lakeside Mtns West of study area.

North Recharge Area: (SHEET 6) — Carter Canyon Drainage, AREA = 94,240,000 ft²

Central Recharge Area: (SHEET 7) — Drainages South of Carter Canyon to Dead Cow Point. AREA = 109,600,000 ft²

South Recharge Area: (SHEET 8) — South of Dead Cow Point, AREA = 49,280,000 ft²

PRECIPITATION:

Based on Tech Pub No. 42 (Stephens, 1974), the average percent of precipitation contributing to groundwater recharge for the periphery of the Northern Great Salt Lake Desert, which includes the Lakeside Mtns, is 3%. Because the Lakeside Mountains aren't specifically addressed in T.P.-42, this analysis conservatively assumed 5% of precipitation contributes to recharge.

The 4 closest precipitation stations to the study area from the Western Regional Climate Center website (www.wrcc.dri.edu) by the Desert Research Institute are:

Period of Record	Sta. Name	Lat.	Lon.	Elev.
09/1989 – 12/2003	Utah Test Range	41°03′	112°56′	4440′
05/1983 – 12/2003	Knolls 10 NE	40°44′	113°12′	4240′
05/1967 – 10/1984	Callister Ranch	40°41′	112°40′	4260′
01/1956 – 12/2003	Grantsville	40°36′	112°27′	4290′

Use Grantsville, Knolls 10 NE, & Utah Test Range to obtain average annual precipitation from 1999 to 2003 (Recent for calibration)

	1999	2000	2001	2002	2003	Avg
Utah Test Range	X	X	6.09	6.96	8.34	7.1 in
Grantsville	X	11.85	X	7.08	6.92	8.6 in
Knolls 10 NE	X	3.78	X	X	5.0	4.4 in

Ave = 6.7 in
= 0.56 ft/yr

X = missing data or incomplete data

Use Callister Ranch & Grantsville to obtain annual precipitation under maximum expected conditions from 1980 – 1983

	1980	1981	1982	1983	Ave
Callister Ranch	15.73	13.07	15.65	15.50	15.5 in
Grantsville	12.67	13.06	13.43	20.78	16.2 in

Ave = 15.9 in
= 1.325 ft/yr

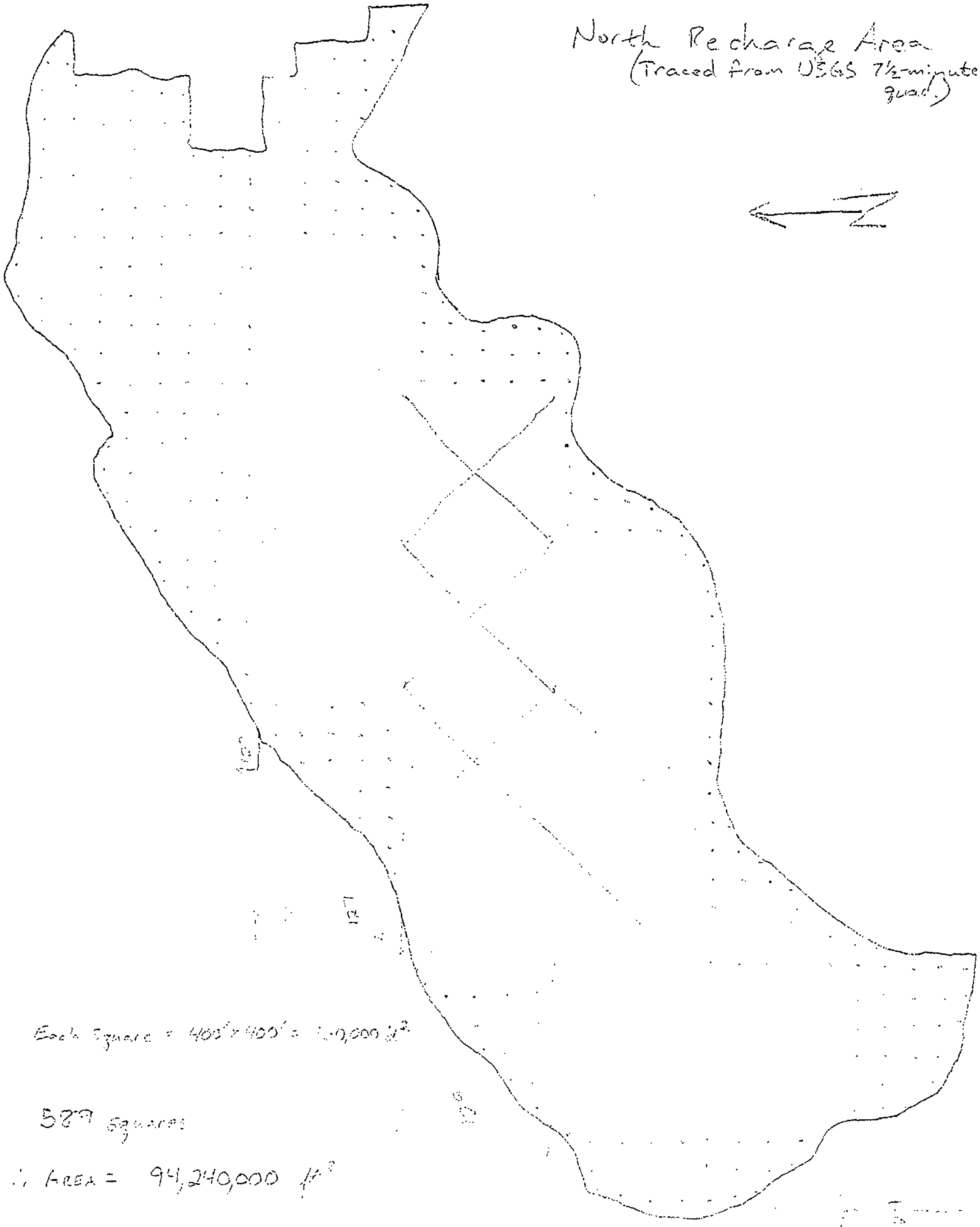
ALLEN & LUCE inc
ENGINEERS

PROJECT: Wasatch Regional Landfill Permit
FEATURE: Modflow Model - GW Simulations
PROJECT NO: 113.30.100

COMPUTED: [illegible]
CHECKED: [illegible]
DATE: 8/25/04

1" = 2000'

North Recharge Area
(Traced from USGS 7½-minute quad.)



Each Square = 400' x 400' = 160,000 ft²

589 squares

∴ AREA = 94,240,000 ft²

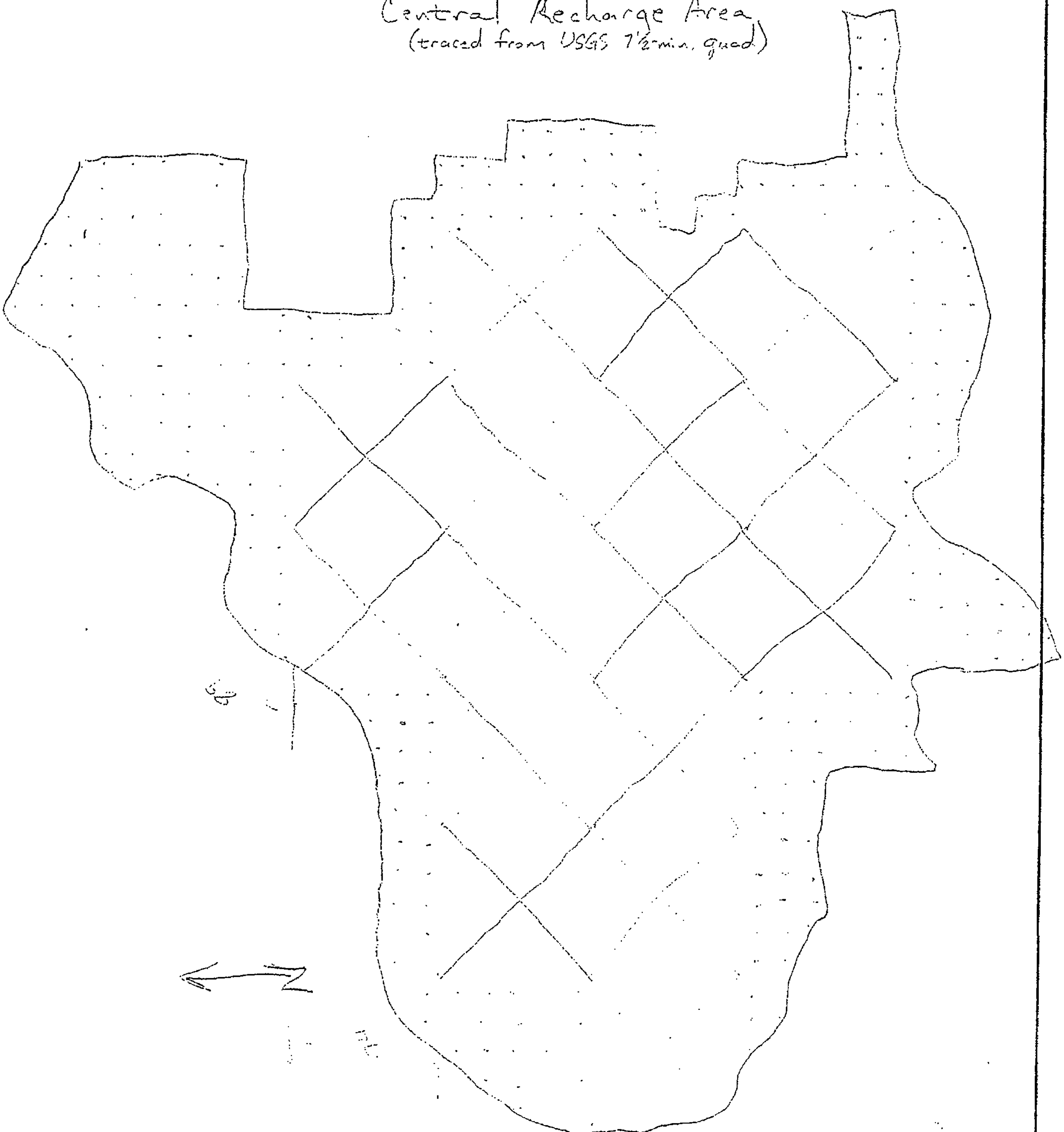
HANSEN ALLEN & LUCE inc ENGINEERS

PROJECT Wasatch Regional Landfill Permit
FEATURE Modflow Model - GW Simulations
PROJECT NO 113.30.100

COMPUTED
CHECKED
DATE 8/23/04

1" = 2000'

Central Recharge Area
(traced from USGS 7½-min. quad)



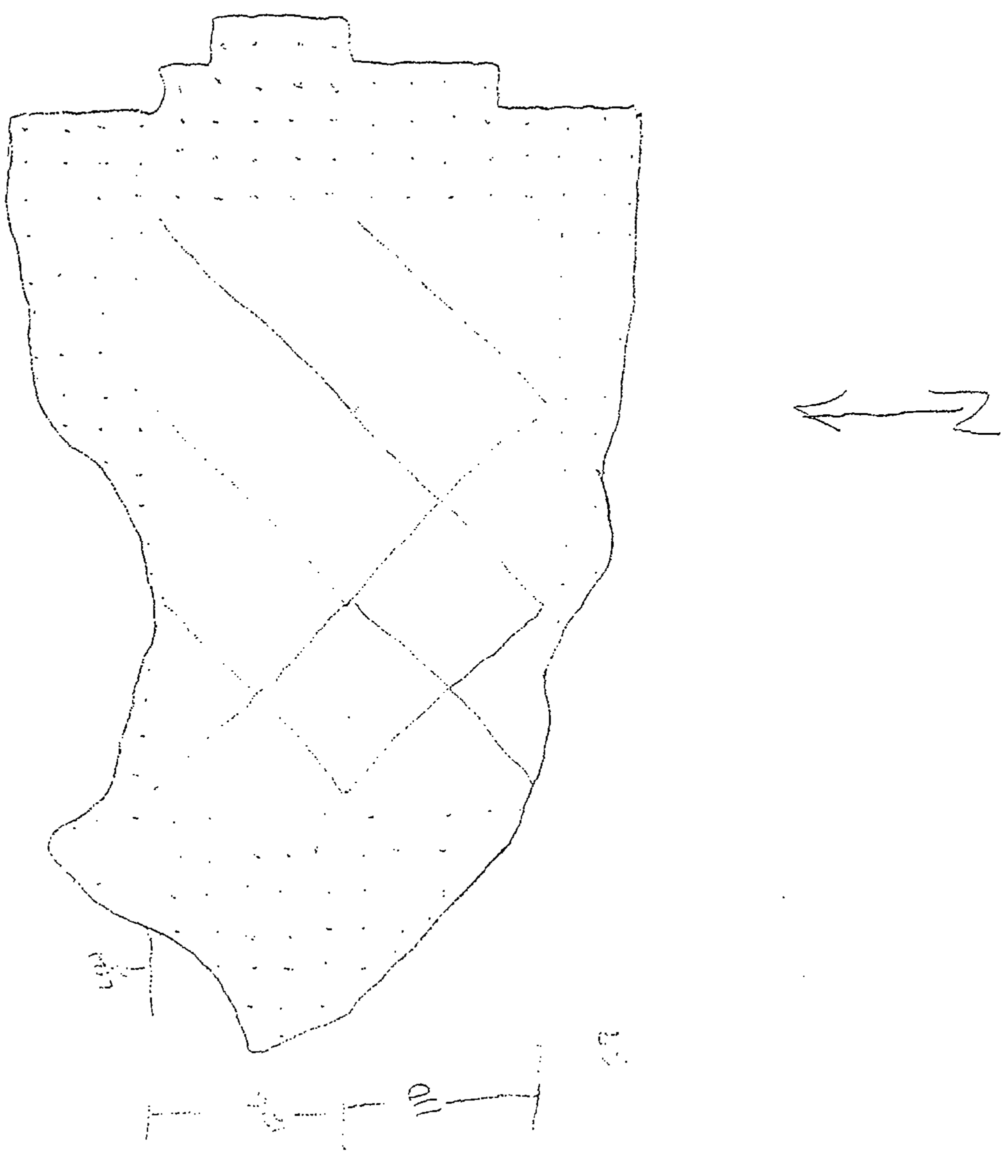
Each Square = 400' × 400' = 160,000 ft²

685 Squares

AREA = 109,600,000 ft²

1" = 2000'

South Recharge Area
(Traced from USGS 7½-min quad)



Each Square = 400' x 400' = 160,000 ft²

308 squares

AREA = 49,280,000 ft²

Total Precipitation by Recharge Area

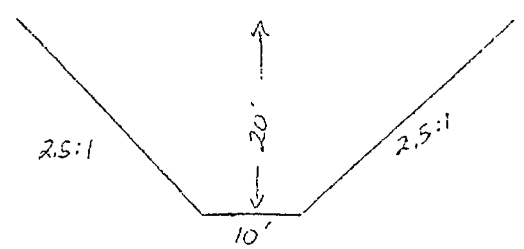
		North	Central	South
1999-2003	Total Volume (ft³/day)	144,587	168,153	75,608
	Volume Recharged (ft³/day)	7,229	8,408	3,780
	# Cells	12	21	13
	Average Volume/cell (ft³/day)	602	400	291
1980-1983	Tot. Vol. (ft³/day)	342,104	397,863	178,893
	Vol. Recharge (ft³/day)	17,105	19,893	8,945
	# cells	12	21	13
	Average Volume/cell (ft³/day)	1,425	947	688

Concentrate more of the recharge at mouths of canyons. Distribution by fraction of the average volume/cell (shown above) is shown on SHEET 10. For example, in the north recharge area the cells at the mouth of Carter Canyon have 2 times the average volume/cell and the cells furthest from the mouth of Carter Canyon have half the average volume/cell so the overall volume for the recharge area is unchanged.

DRAIN (for future construction to control groundwater)

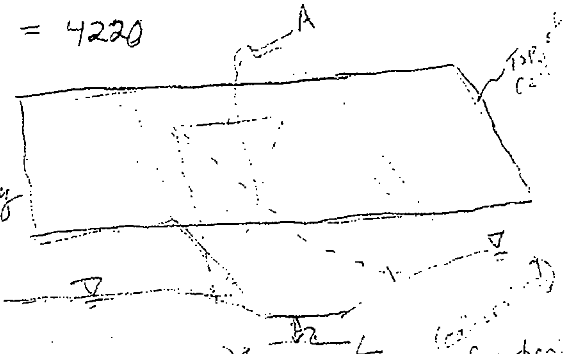
Model an open trench @ low end of facility as a drain

Cross-section



Lowest elevation of Drain = 4220

Conductance = $C = \frac{kA}{L}$

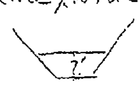


k = hydraulic conductivity
A = plan area of drain
L = flow length through bed of drain

The 90% assumption was checked by [illegible] 50% of model K; the resulting contours were identical.

k – Due to soil disturbance from construction, use 90% of model K for drain bed.

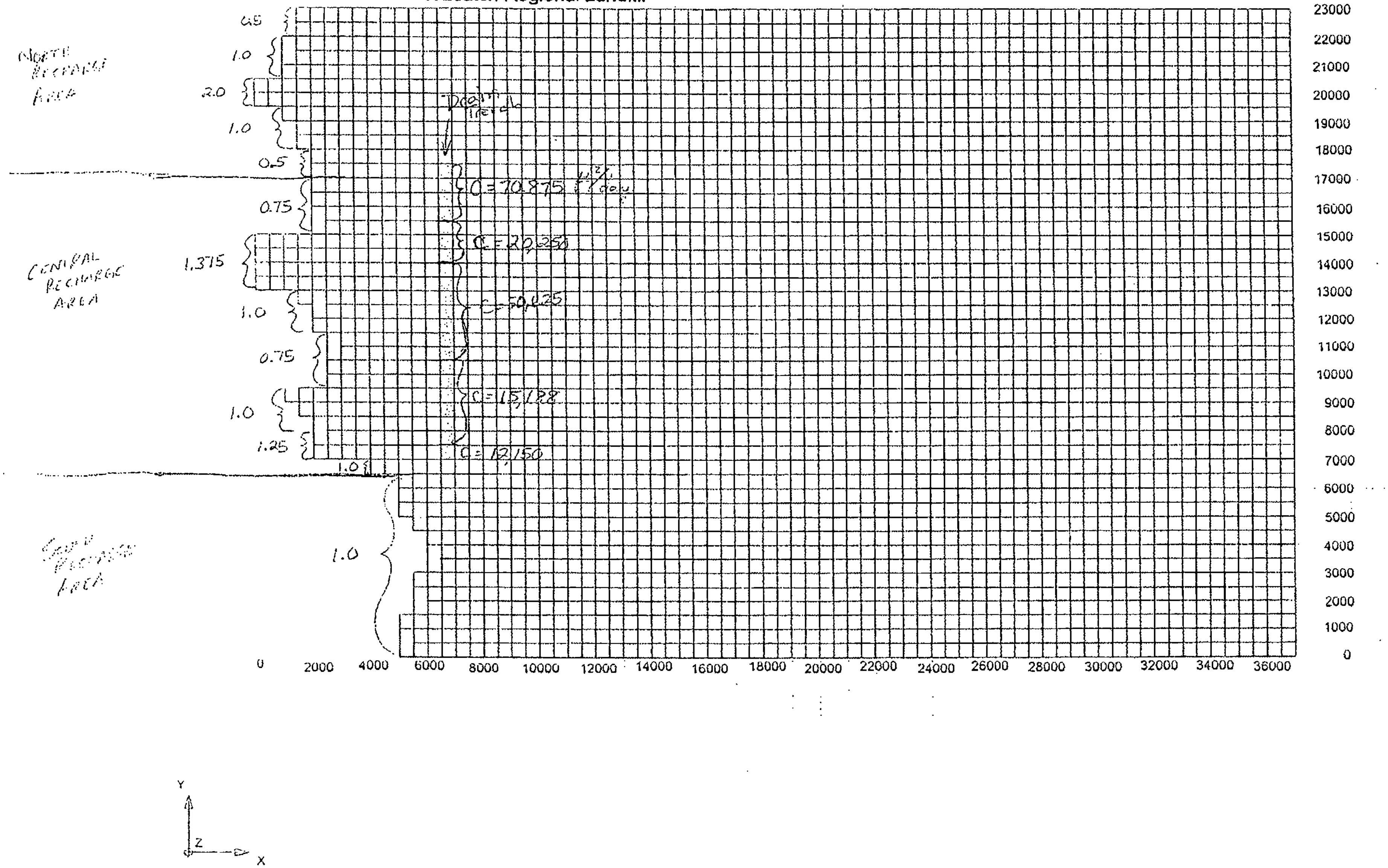
A – assume top width of cross-section above @ depth of 7' & length of 1 model cell (500')



Top width = 7×2×2.5 + 10 = 45'

L – assume a drain bed thickness of 2 feet (Maximum depth impacted by construction)

Wasatch Regional Landfill -



10/17

DRAIN (continued)

Model in the column of cells between 6,500′ and 7,000′ of the study area grid (column 14 or J:14) which is just east of the proposed landfill from row 12 (I:12) to row 32 (I:32) (or 7000′ to 17,500′ of the grid)

$$C = \frac{k(500\,ft)(45\,ft)}{2\,ft} = (11{,}250\,ft)(k)$$ ⇒ results in Conductance per cell (SEE SHEET 10)

Row(s)	MODEL K (ft/day)	k (ft/day)	C (ft²/day)
12–15	7	6.3	70,875
16–18	2	1.8	20,250
19–25	5	4.5	50,625
26–31	1.5	1.35	15,188
32	1.2	1.08	12,150

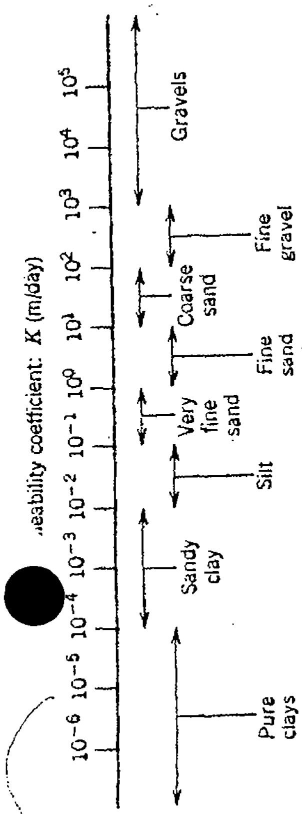


FIGURE 9.4 Range of permeability in soils.

From "Hydrology: Water Quantity and Quality Control" by Wanielista, Kersten & Eaglin (1997) Published by John Wiley & Sons

HYDRAULIC CONDUCTIVITY

Hydraulic Conductivity was assumed to vary by location in the model based on influence from drainages, mud flats, or the Great Salt Lake. The distribution of hydraulic conductivity zones is shown on SHEET 12. Initial hydraulic conductivity values were chosen based on typical values for the types of materials encountered in the Kleinfelder borings. Soils consisted mostly of sands, silts, and clays. There were some gravels found near the mountains but these even had a silt & sand matrix. Wanielista, et. al. (1997) reports a range of 0.3–30 ft/day for fine & coarse sands. An initial value of 7 ft/day was entered before calibration.

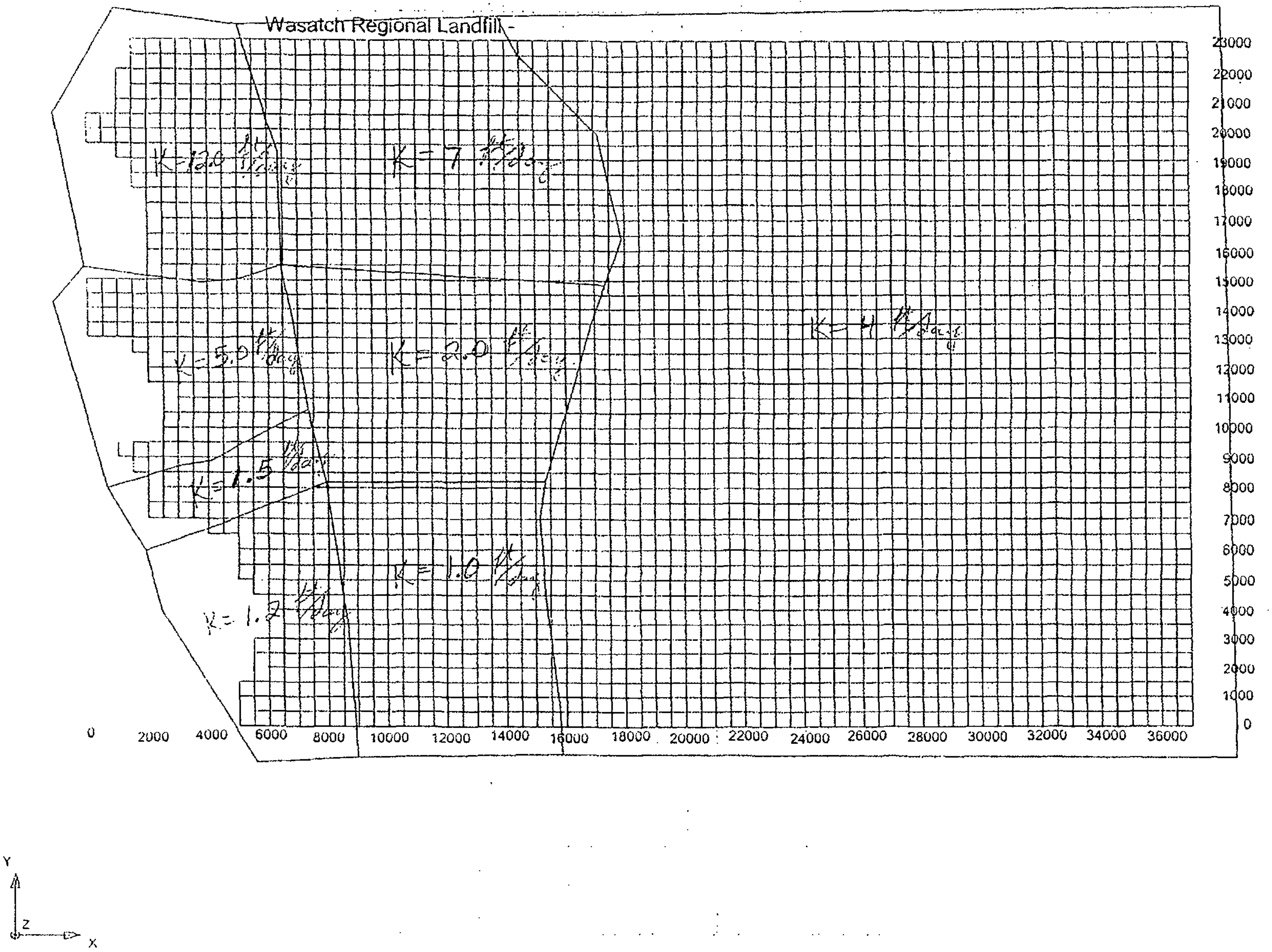
MODEL CALIBRATION

The hydraulic conductivity was varied to calibrate the computed groundwater levels to the measured groundwater levels from the borehole data assuming recharge & lake levels from 2003. The calibrated hydraulic conductivities are shown on sheet 12. Calibrated gw levels with calibration targets are on SHEET 13. Calibration targets show ± 3 feet with a 95% confidence interval for computing standard deviation.

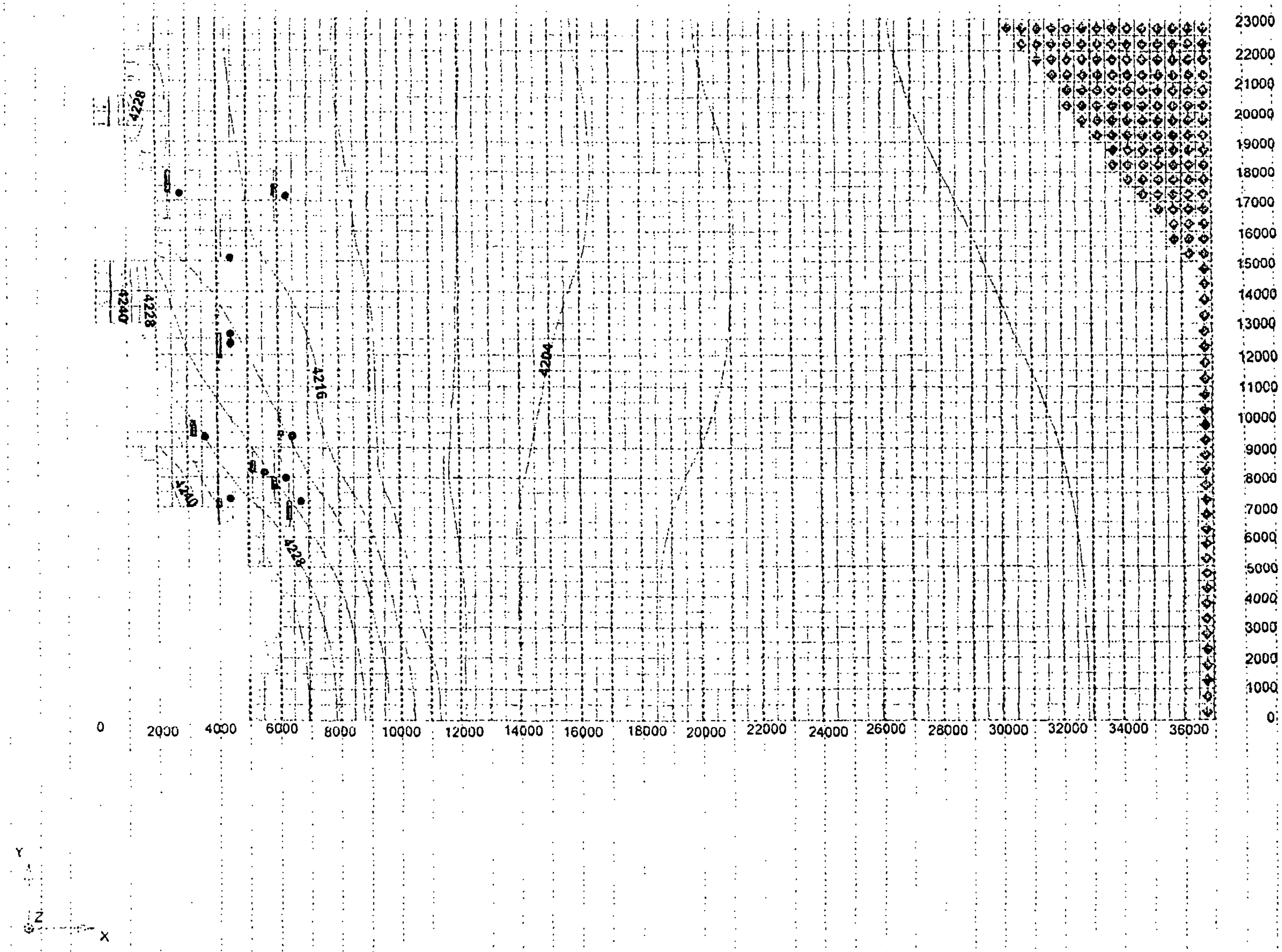
MODEL RESULTS

SEE SHEETS 14–16

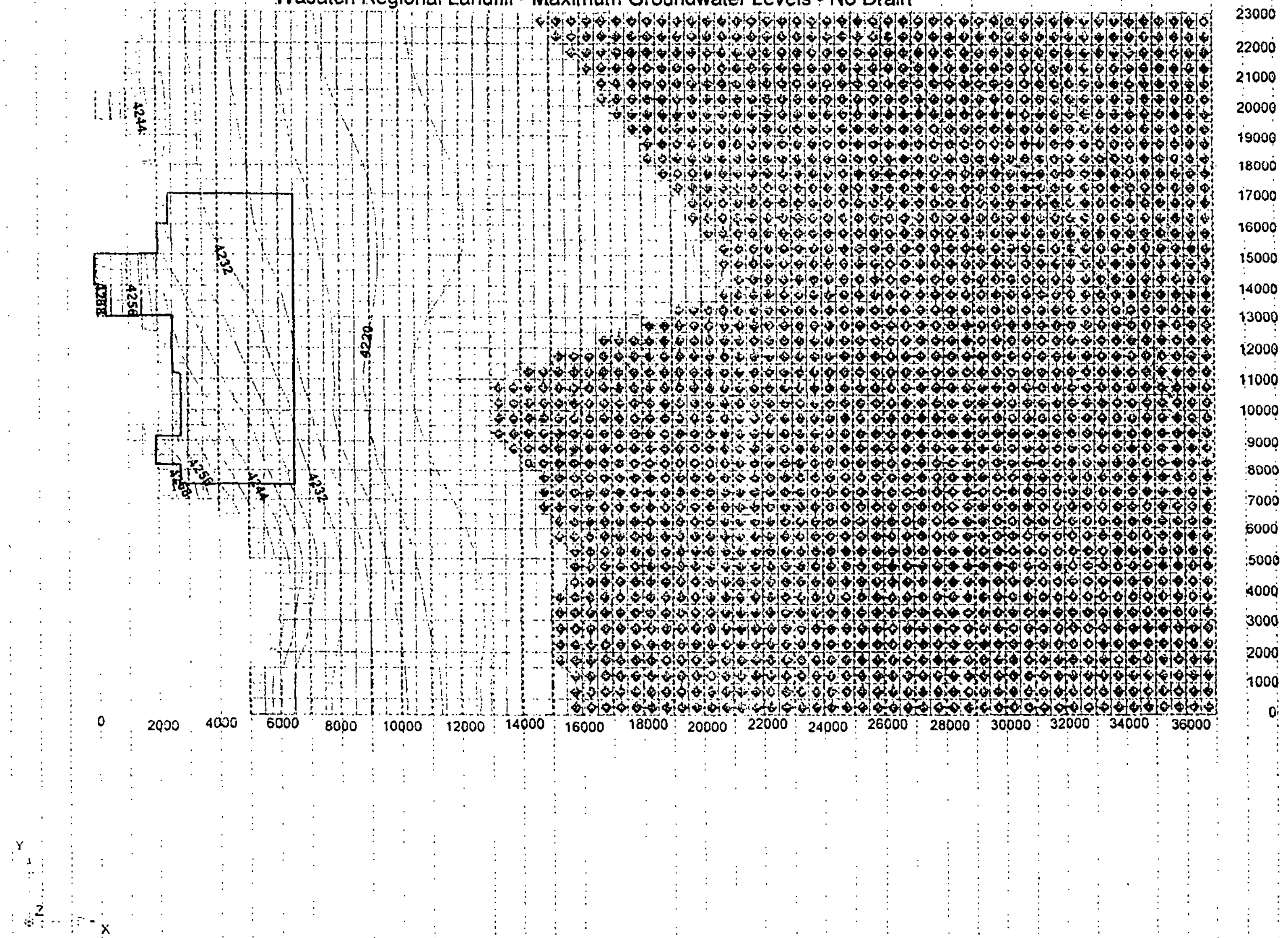
The computed GW contours shown on Sheets 14–16 were overlain onto the landfill cell layout. Bottom elevations for the landfill were chosen a minimum of 6′ above the maximum projected computed groundwater level. (allow for "freeboard")

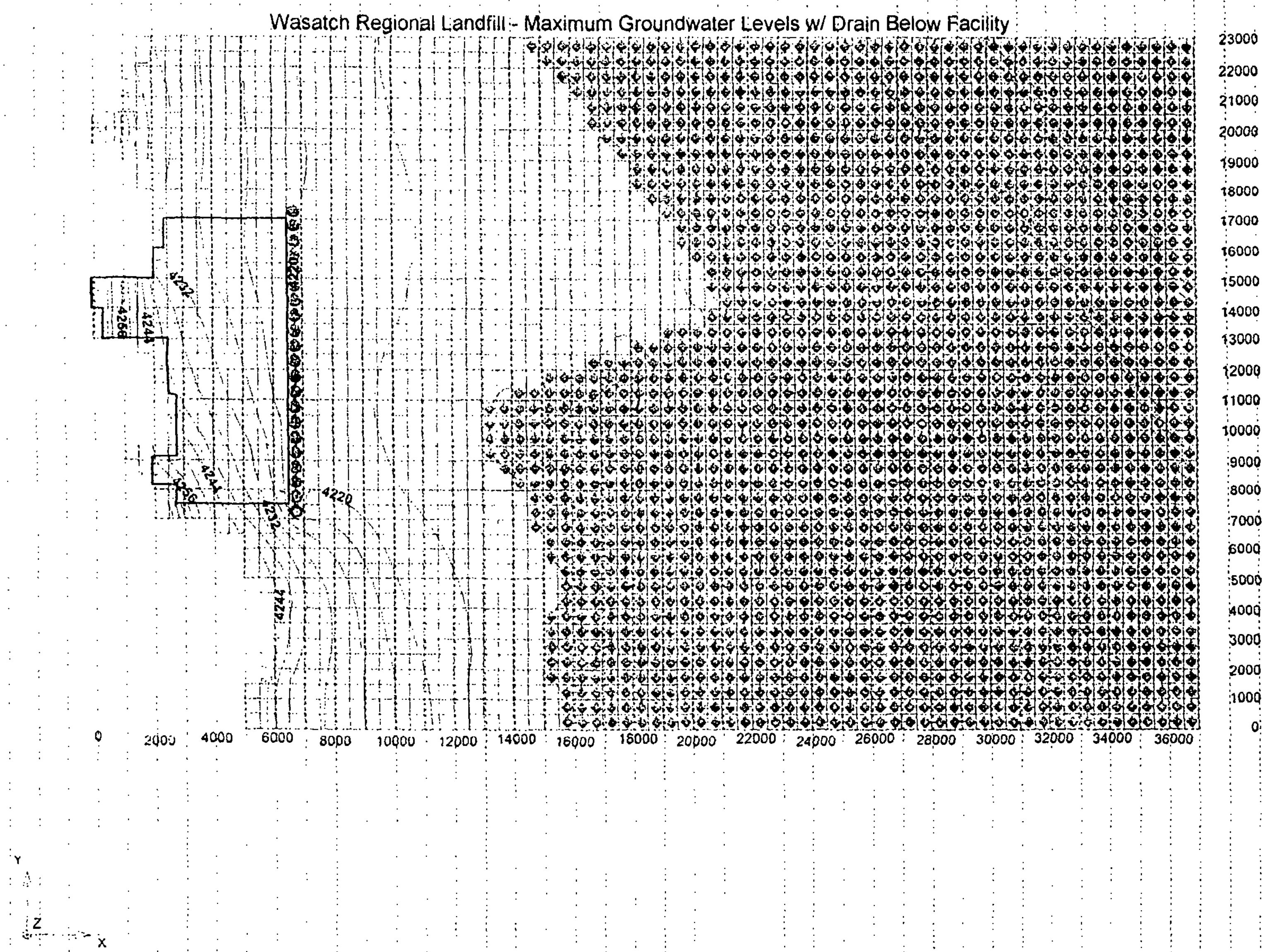

Wasatch Regional Landfill -
K=12.0 ft/day
K=7 ft/day
K=5.0 ft/day
K=2.0 ft/day
K=4 ft/day
K=1.5 ft/day
K=1.0 ft/day
K=1.2 ft/day
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000
30000
32000
34000
36000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Y
Z
X

4/21


4228
4240
4228
4216
4204
4240
4228
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000
30000
32000
34000
36000
Y
Z
X

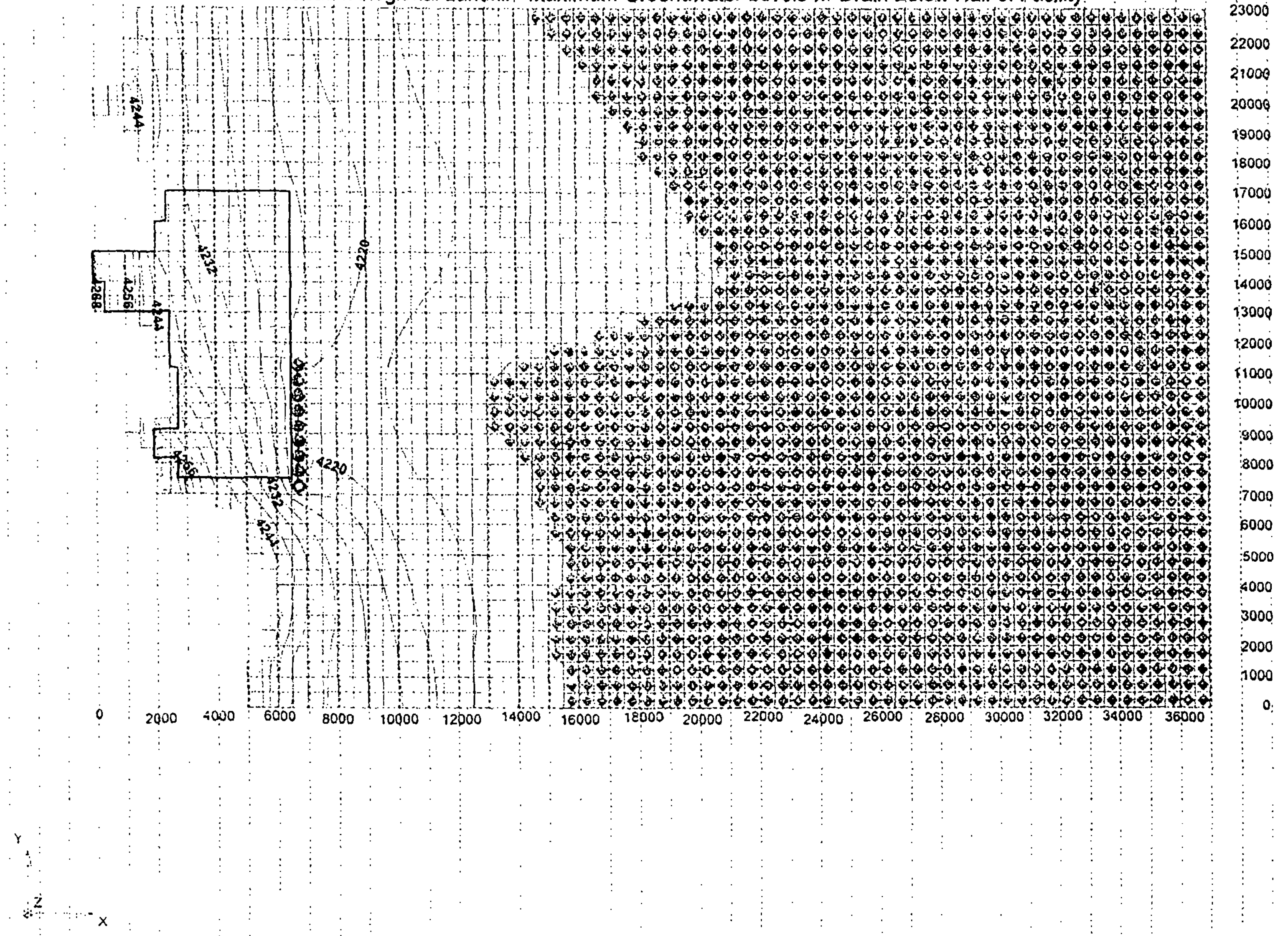
Wasatch Regional Landfill - Maximum Groundwater Levels - No Drain

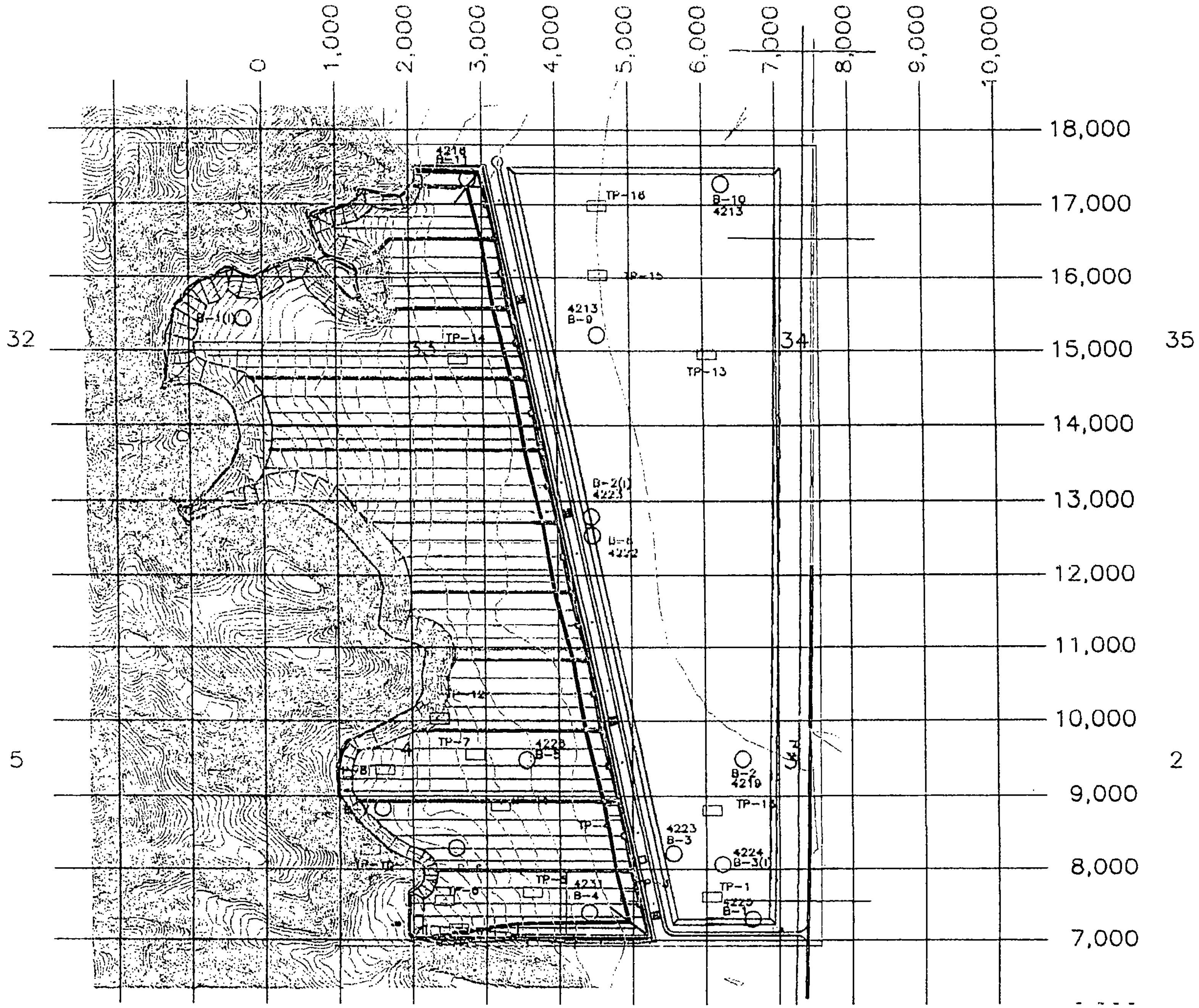




Wasatch Regional Landfill - Maximum Groundwater Levels w/ Drain Below Facility
4220
4232
4244
4256
4268
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000
30000
32000
34000
36000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Y
Z
X

Wasatch Regional Landfill - Maximum Groundwater Levels w/ Drain Below Half of Facility





0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
32
35
34
5
2
4218
B-11
TP-16
B-10
4213
TP-15
4213
B-9
B-1(I)
TP-14
TP-13
B-2(I)
4223
4222
TP-12
TP-7
4228
B-5
B-2
4219
TP-1
4223
B-3
4224
B-3(I)
TP-3
4231
B-4
TP-1
B-1

HANSEN ALLEN & LUCE inc

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SHEET 1 OF 5
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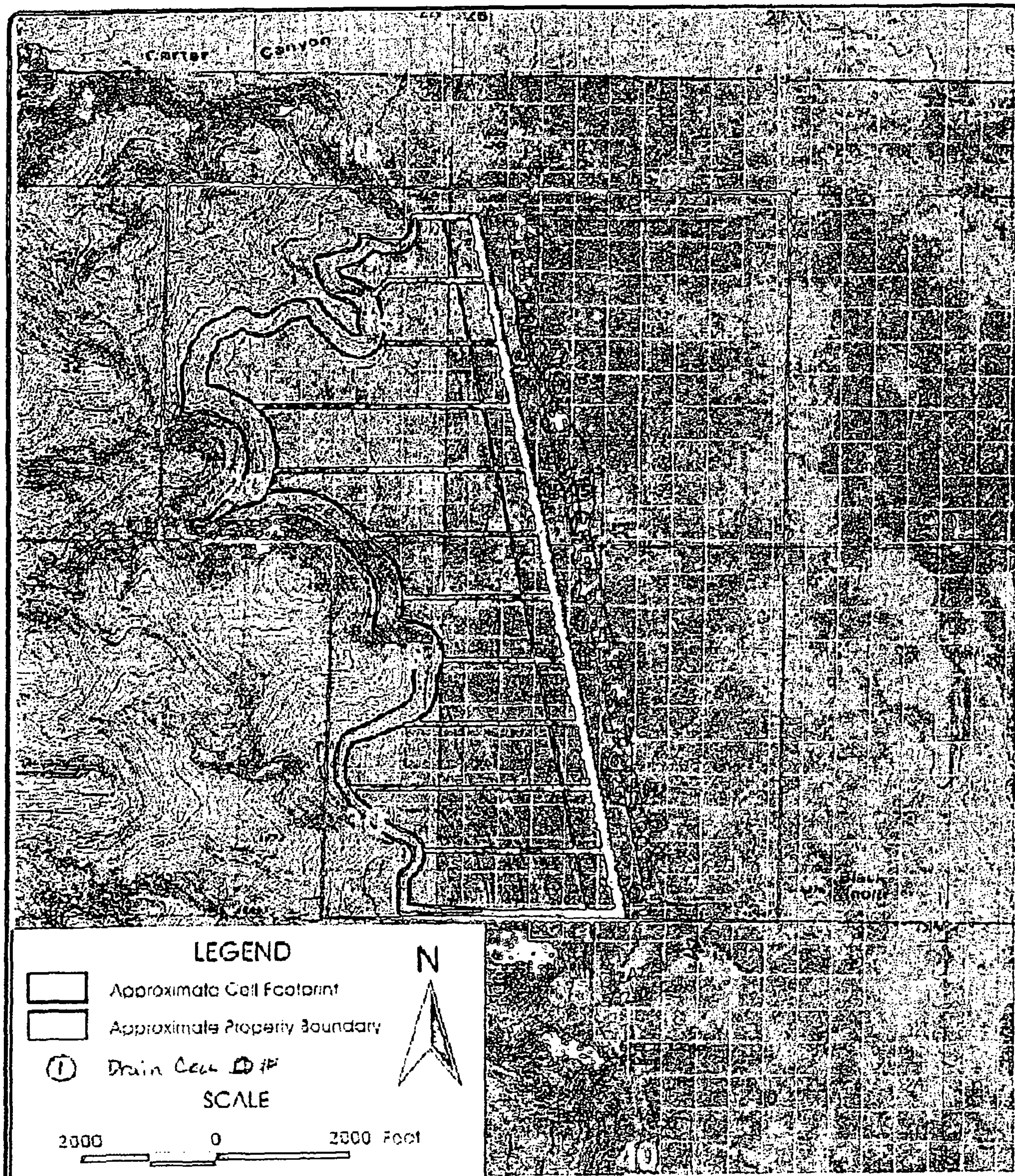
CHECKED [illegible]
DATE [illegible]

[illegible]

[illegible]

Drain Cell #	Column	Row	Top Width	Length in Cell	Area	Bed Length	Model K	Conductance
25	8	12	45	330	14850	2	12	80190
24	8	13	45	510	22950	2	12	123930
23	8	14	45	510	22950	2	12	123930
22	8	15	45	510	22950	2	12	123930
21	8	16	45	210	9450	2	12	51030
20	9	16	45	300	13500	2	12	72900
19	9	17	45	510	22950	2	5	51637.5
18	9	18	45	510	22950	2	5	51537.5
17	9	19	45	510	22950	2	5	51637.5
16	9	20	45	390	17550	2	5	39487.5
15	10	20	45	120	5400	2	5	12150
14	10	21	45	510	22950	2	5	51637.5
13	10	22	45	510	22950	2	5	51637.5
12	10	23	45	510	22950	2	5	51637.5
11	10	24	45	510	22950	2	5	51637.5
10	10	25	45	210	9450	2	5	21262.5
9	11	25	45	300	13500	2	5	30375
8	11	26	45	510	22950	2	5	51637.5
7	11	27	45	510	22950	2	5	51637.5
6	11	28	45	510	22950	2	1.5	15491.25
5	11	29	45	350	15750	2	1.5	10631.25
4	12	29	45	160	7200	2	1.5	4860
3	12	30	45	510	22950	2	1.5	15491.25
2	12	31	45	510	22950	2	1.5	15491.25
1	12	32	45	430	19350	2	1.2	10449



~~NEW CELL LAYOUT W/ BORROW~~
NEW DRAIN TRENCH LOCATION

FIGURE
??

HANSEN ALLEN & LUCE INC

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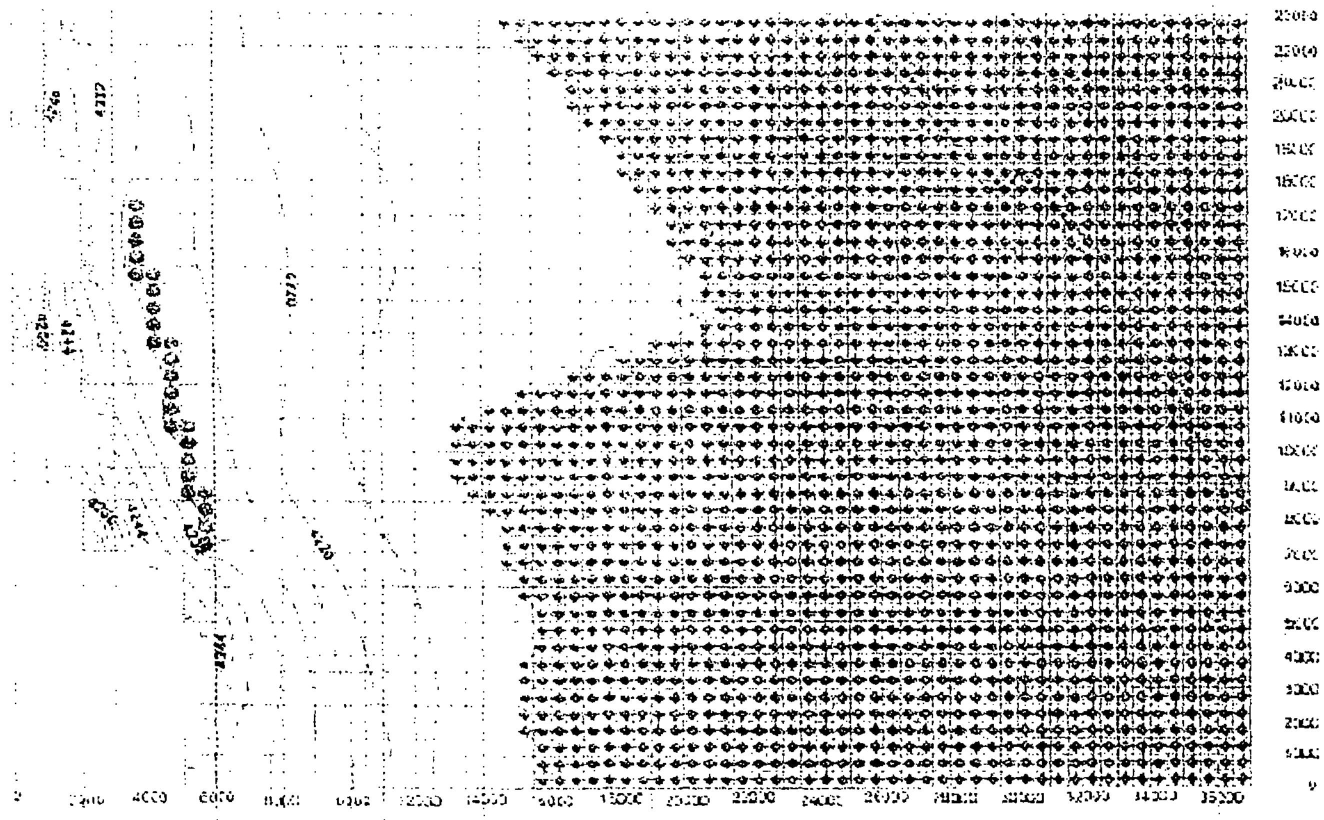
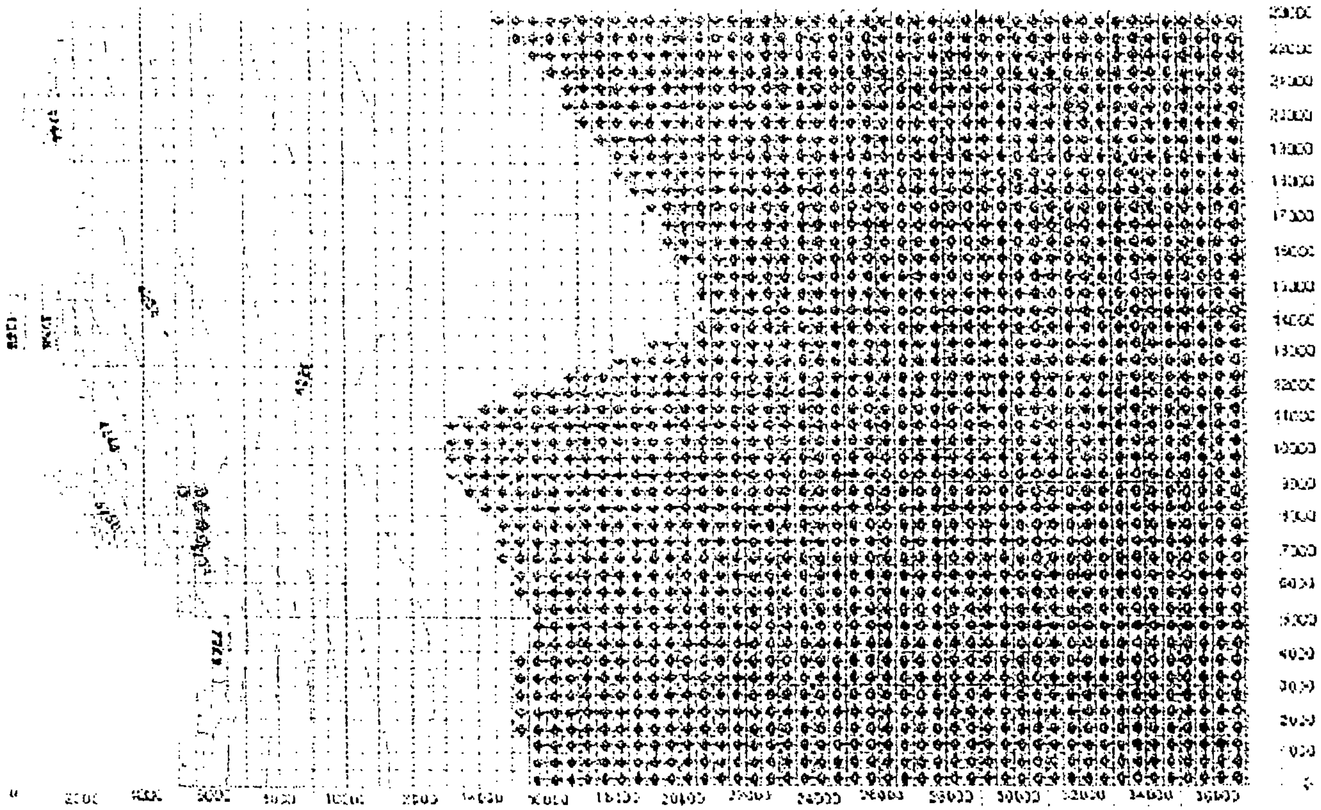




STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 42

HYDROLOGIC RECONNAISSANCE OF THE NORTHERN GREAT SALT LAKE DESERT AND SUMMARY HYDROLOGIC RECONNAISSANCE OF NORTHWESTERN UTAH

by

Jerry C. Stephens, Hydrologist

U. S. Geological Survey

Prepared by

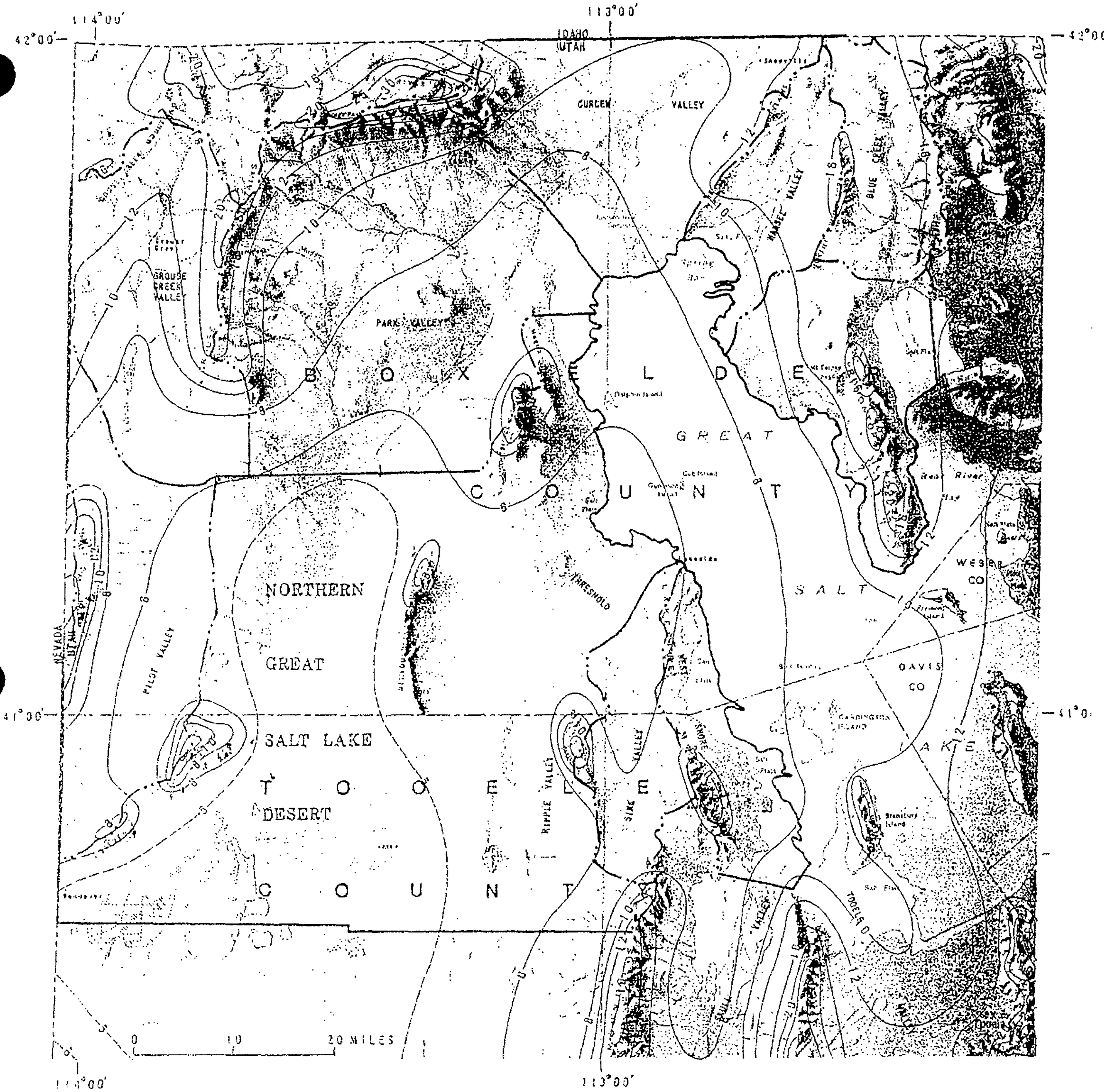
the United States Geological Survey

in cooperation with

the Utah Department of Natural Resources

Division of Water Rights

1974



EXPLANATION

5 — Line of equal normal annual precipitation, 1931-60; interval 2 and 4 inches; supplementary 5-inch line and adjusted lines near State line dashed

Drainage divide } Hydrologic subarea boundary
Arbitrary boundary }

Base from U.S. Geological Survey 1959 State of Utah 1:500,000 shaded relief

Climatologic data from U.S. Weather Bureau (1963). Adjusted along State line to reconcile with Nevada data (Hardman, 1965) by J. W. Hood and J. C. Stephens

Figure 1.—Map showing location, physiography, precipitation, and hydrologic subarea boundaries of northwestern Utah.

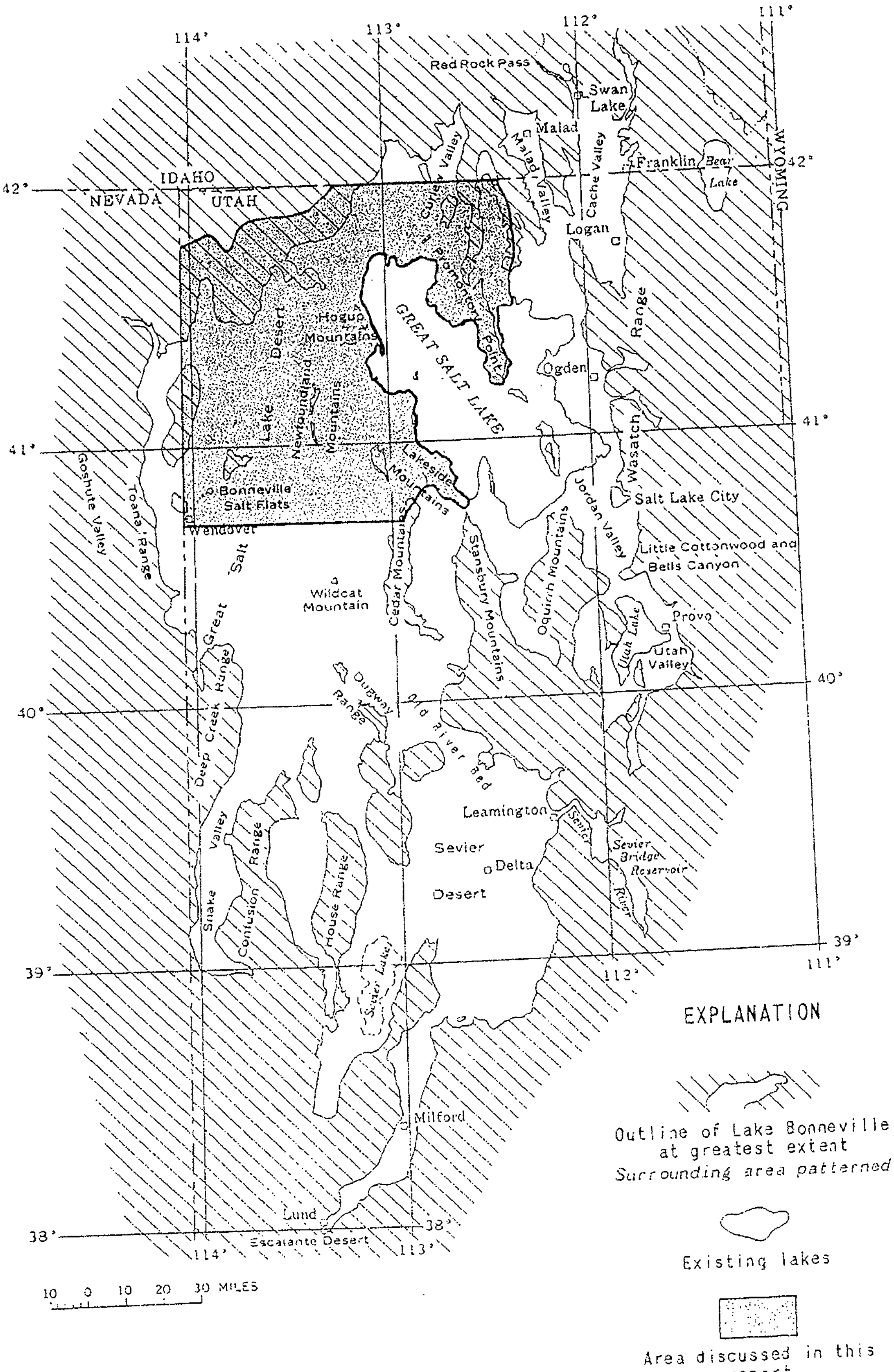


Figure 2.—Map of Lake Bonneville (after Crittenden, 1963).

Table 3.-Estimated average annual volumes of precipitation and ground-water recharge in the northern Great Salt Lake Desert
(Areas of precipitation zones measured from isohyetal and geologic maps, figure 1 and plate 1)

Precipitation zone (inches)	Locality	Area (acres)	Precipitation		Recharge	
			Feet	Acre-feet	Percent of precipitation	Acre-feet
		Consolidated rocks and alluvium				
8-more than 12	West slope Grassy Mountains	7,810	0.88	6,870	8	550
Do	East slope Silver Island Range	10,880	0.88	9,570	8	770
8-more than 10	Terrace and Hogup Mountains	19,260	0.80	15,410	8	1,230
6-more than 8	Newfoundland Mountains	9,020	0.63	5,680	3	170
6-8	Periphery of northern Great Salt Lake Desert	91,650	0.58	53,150	3	1,590
5-6	Flanks of Newfoundland Mountains	24,700	0.46	11,360	2	230
Subtotal		163,320		102,040		4,540
		Lakebed deposits and dune sand				
6-8	Periphery of northern Great Salt Lake Desert	14,530	0.58	8,430	0	0
5-6	Floor of northern Great Salt Lake Desert	648,000	0.46	298,000	0	0
Less than 5	Central part of northern Great Salt Lake Desert	431,000	0.40	172,000	0	0
Do	Bonneville Salt Flats (crystalline salt beds)	96,000	0.40	38,400	(1/)	20,000
Subtotal		1,189,530		516,830		20,000
Total (rounded)		1,350,000		620,000		25,000

1/ See page 13 for discussion of recharge estimate for crystalline salt beds.

APPENDIX 5.2
Groundwater Levels and Elevations

MONITORING WELL 1
GROUNDWATER LEVELS
AND ELEVATIONS

GROUND WATER CONTROLS MUST BE IMPLEMENTED AST ELEVATION = 4232

MEASUREMENT DATA	REFERENCE ELEVATION	MEASURED DEPTH	GROUNDWATER ELEVATION
09/25/05	4252.29	23.18	4229.11
10/21/05	4252.29	23.82	4228.47
03/29/06	4252.29	24.10	4228.19
06/21/06	4252.29	24.05	4228.24
09/13/06	4252.29	23.94	4228.35
10/30/06	4252.29	24.03	4228.26
03/22/07	4252.29	24.20	4228.09
06/12/07	4252.29	24.30	4227.99
10/16/07	4252.29	24.36	4227.93
03/26/08	4252.29	24.55	4227.74
10/22/08	4252.29	24.64	4227.65
04/22/09	4252.29	24.66	4227.63
10/01/09	4252.29	24.21	4228.08

MONITORING WELL 2 GROUNDWATER LEVELS AND ELEVATIONS GROUND WATER CONTROLS MUST BE IMPLEMENTED AST ELEVATION = 4232			
MEASUREMENT DATA	**REFERENCE ELEVATION**	**MEASURED DEPTH**	**GROUNDWATER ELEVATION**
09/25/05	4250.91	23.55	4227.36
10/21/05	4250.91	23.65	4227.26
03/29/06	4250.91	23.64	4227.27
06/21/06	4250.91	23.50	4227.41
09/13/06	4250.91	23.49	4227.42
10/30/06	4250.91	23.71	4227.20
03/22/07	4250.91	23.38	4227.53
06/12/07	4250.91	23.30	4227.61
10/16/07	4250.91	23.03	4227.88
03/26/08	4250.91	23.23	4227.68
10/22/08	4250.91	23.41	4227.50
04/22/09	4250.91	23.17	4227.74
10/01/09	4250.91	23.07	4227.84

MEMORANDUM

TO: Darin Olson
Hansen, Allen & Luce, Inc. Project File
Wasatch Regional Groundwater Control Plan, January 2008

FROM: Hansen, Allen & Luce, Inc.

DATE: October 14, 2009

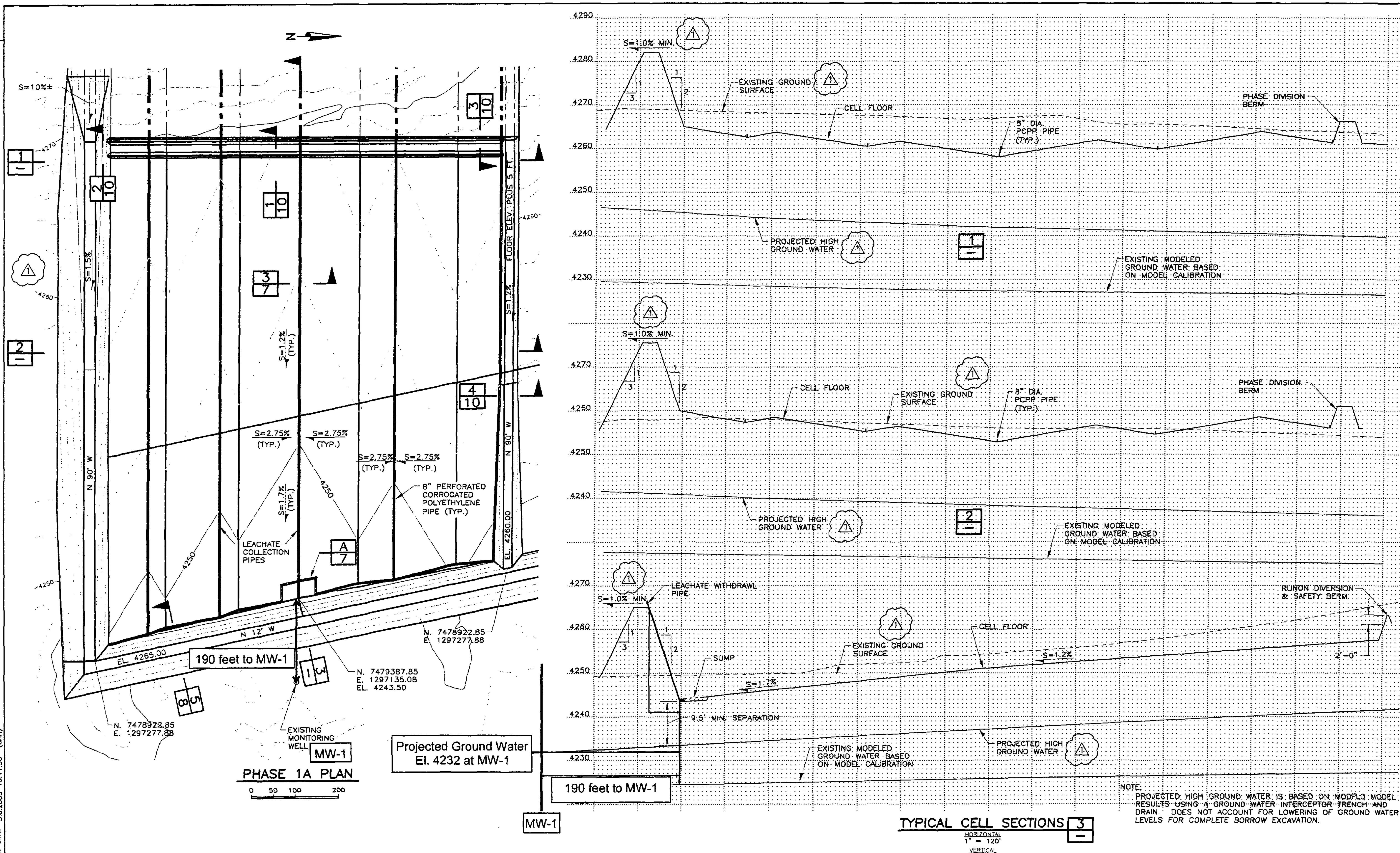
RE: Formal Documentation - Determination of Groundwater Elevations for Implementing Groundwater Controls at Wasatch Regional Landfill

The Wasatch Regional Landfill - Design Engineering Report dated December 2004 and revised June 2005 provides for a ground water control trench to maintain ground water levels below the 5-foot separation requirement stipulated in the Utah Solid Waste Permitting and Management Rules - Utah Administrative Code R315-301 through 320 for a lined Municipal Solid Waste (Class V) landfill.

A ground water model was developed during design of the landfill that incorporated atmospheric, soil, and Great Salt Lake characteristics to determine historic high groundwater levels. The groundwater model was also used to estimate the affects of a trench that could provide borrow material for landfill construction, daily cover, and closure and that could provide a physical barrier to control affects of the Great Salt Lake levels on groundwater levels at the site.

Due to limitations within the model to exactly match measured ground water levels at the time of design and permitting of the landfill, the Utah Division of Solid and Hazardous Waste (UDSHW) required the groundwater control trench be designed to provide for 9.5 feet of separation (providing a 4.5-foot safety margin) between groundwater and the bottom lining system. In order to accomplish the parameters set by the UDSHW, the bottom of the west side of the trench parallel to the east landfill cell embankments would be excavated to an elevation of 4227. During construction of the first phase of the landfill area, the trench was excavated to the 4227 elevation immediately east of the phase I area. The trench excavation provided moist conditions associated with ground water and conditions where run-off water could pond. The presence of moisture and of a water source resulted in attraction of greater bird populations at the landfill. A ground water control plan was subsequently prepared and implemented in order to minimize the affects of the bird population. The intent of the plan is to allow complete excavation of the trench depth to be delayed until groundwater levels are high enough to begin encroaching on the 9.5-foot separation provided for in the landfill design. An elevation of 4232 was determined to provide the groundwater action level that would require full implementation or construction of the trench immediately east of the landfill phases in operation.

The elevation of 4232 was determined by extending the maximum groundwater surface profile provided on Sheet 6 of the Design Engineering Report to the location of the monitoring well located east of landfill. The elevation of the groundwater surface profile at the monitoring well provided the 4232 elevation for full implementation of groundwater controls. An elevation of 4230.5 was provided as the elevation to begin planning for implementation of the groundwater controls. The attached drawing (Sheet 6) shows the projection of the groundwater surface profile to the monitoring well location that was used to determination the groundwater action levels.



FILE NAME: 113\30.100\CADFILES\PERMIT DWGS\PHASE 1 PLAN__R1.DWG
FILE DATE: 5.6.2005 10:11:36 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS		DESIGNED MPW, KCS	3					SCALE AS SHOWN	WASATCH REGIONAL	WASATCH REGIONAL LANDFILL FACILITY
		DRAFTED DRB	2							PHASE 1A PLAN & SECTIONS
		CHECKED KCS	1	05/2005	ADDED SLOPE CALLOUTS, NEW CONTOURS, MODIFIES EXISTING GROUND SURFACE & PROJECTED HIGH WATER	CAH	KCS			SHEET 6
	PROJECT ENGINEER	DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APVD.			113-30-100

APPENDIX 5.2
Groundwater Levels and Elevations

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AND ELEVATIONS

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10/30/06	4252.29	24.03	4228.26
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10/22/08	4252.29	24.64	4227.65
04/22/09	4252.29	24.66	4227.63
10/01/09	4252.29	24.21	4228.08

MONITORING WELL 2 GROUNDWATER LEVELS AND ELEVATIONS GROUND WATER CONTROLS MUST BE IMPLEMENTED AST ELEVATION = 4232			
MEASUREMENT DATA	REFERENCE ELEVATION	MEASURED DEPTH	GROUNDWATER ELEVATION
09/25/05	4250.91	23.55	4227.36
10/21/05	4250.91	23.65	4227.26
03/29/06	4250.91	23.64	4227.27
06/21/06	4250.91	23.50	4227.41
09/13/06	4250.91	23.49	4227.42
10/30/06	4250.91	23.71	4227.20
03/22/07	4250.91	23.38	4227.53
06/12/07	4250.91	23.30	4227.61
10/16/07	4250.91	23.03	4227.88
03/26/08	4250.91	23.23	4227.68
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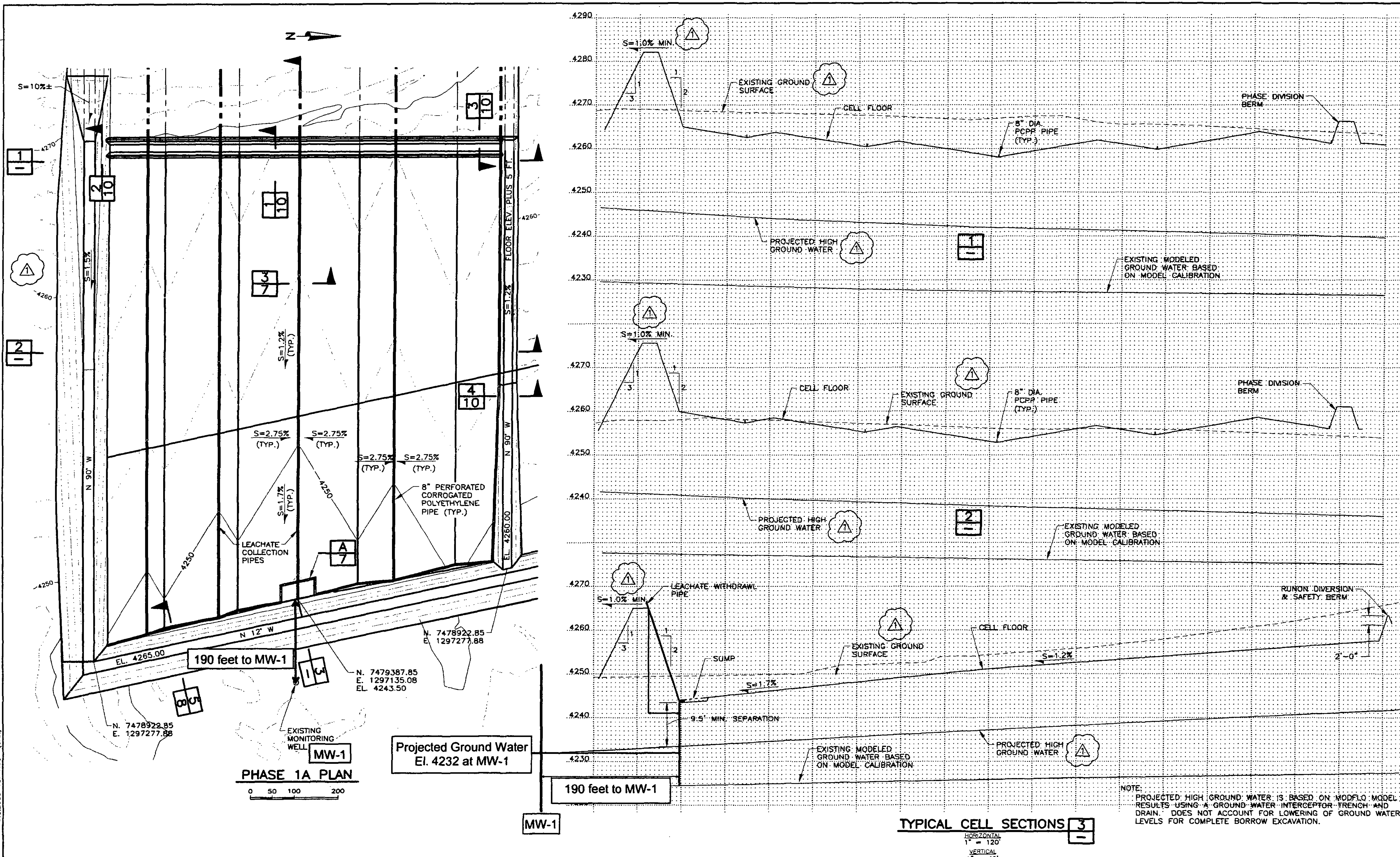
The Wasatch Regional Landfill - Design Engineering Report dated December 2004 and revised June 2005 provides for a ground water control trench to maintain ground water levels below the 5-foot separation requirement stipulated in the Utah Solid Waste Permitting and Management Rules - Utah Administrative Code R315-301 through 320 for a lined Municipal Solid Waste (Class V) landfill.

A ground water model was developed during design of the landfill that incorporated atmospheric, soil, and Great Salt Lake characteristics to determine historic high groundwater levels. The groundwater model was also used to estimate the affects of a trench that could provide borrow material for landfill construction, daily cover, and closure and that could provide a physical barrier to control affects of the Great Salt Lake levels on groundwater levels at the site.

Due to limitations within the model to exactly match measured ground water levels at the time of design and permitting of the landfill, the Utah Division of Solid and Hazardous Waste (UDSHW) required the groundwater control trench be designed to provide for 9.5 feet of separation (providing a 4.5-foot safety margin) between groundwater and the bottom lining system. In order to accomplish the parameters set by the UDSHW, the bottom of the west side of the trench parallel to the east landfill cell embankments would be excavated to an elevation of 4227. During construction of the first phase of the landfill area, the trench was excavated to the 4227 elevation immediately east of the phase I area. The trench excavation provided moist conditions associated with ground water and conditions where run–off water could pond. The presence of moisture and of a water source resulted in attraction of greater bird populations at the landfill. A ground water control plan was subsequently prepared and implemented in order to minimize the affects of the bird population. The intent of the plan is to allow complete excavation of the trench depth to be delayed until groundwater levels are high enough to begin encroaching on the 9.5-foot separation provided for in the landfill design. An elevation of 4232 was determined to provide the groundwater action level that would require full implementation or construction of the trench immediately east of the landfill phases in operation.

The elevation of 4232 was determined by extending the maximum groundwater surface profile provided on Sheet 6 of the Design Engineering Report to the location of the monitoring well located east of landfill. The elevation of the groundwater surface profile at the monitoring well provided the 4232 elevation for full implementation of groundwater controls. An elevation of 4230.5 was provided as the elevation to begin planning for implementation of the groundwater controls. The attached drawing (Sheet 6) shows the projection of the groundwater surface profile to the monitoring well location that was used to determination the groundwater action levels.



HANSEN ALLEN & LUCE INC. ENGINEERS	PROJECT ENGINEER	DESIGNED MPW, KCS	3		
		DRAFTED DRB	2		
		CHECKED KCS	1	05/2005	ADDED SLOPE CALLOUTS, NEW CONTOURS, MODIFIES EXISTING GROUND SURFACE & PROJECTED HIGH WATER — CAH KCS
		DATE DECEMBER 2004	NO.	DATE	REVISIONS — BY APVD.

SCALE: AS SHOWN

WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

PHASE 1A PLAN & SECTIONS

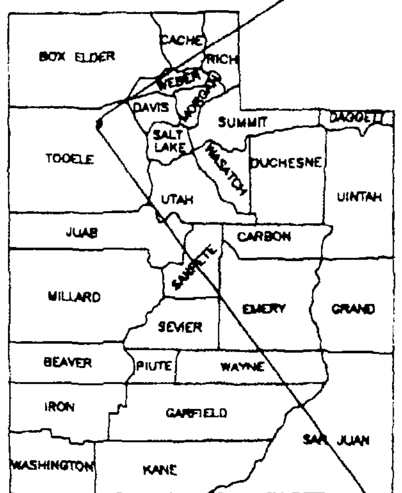
SHEET 6

113-30-100

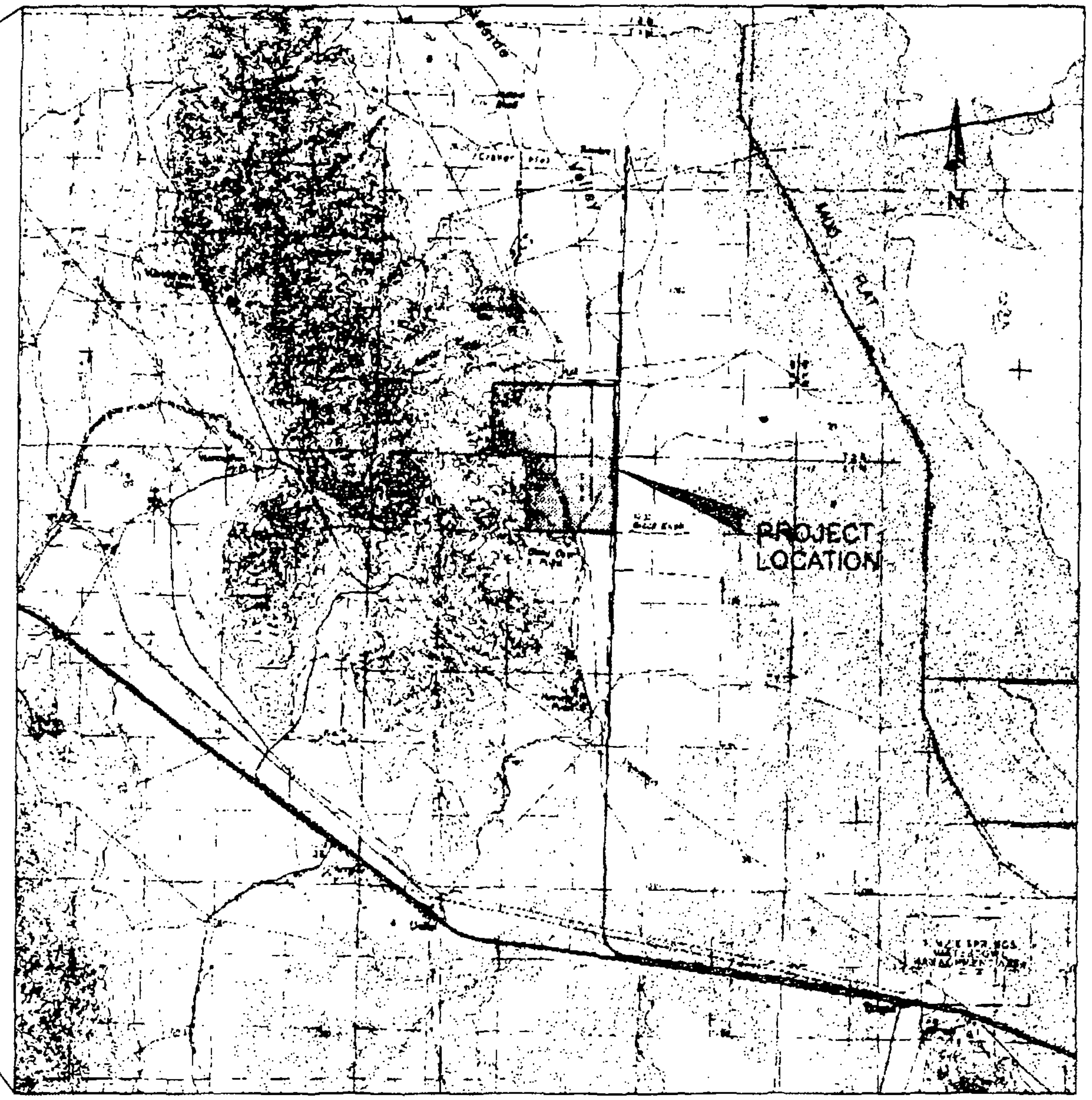
APPENDIX 6
LANDFILL DESIGN (HANSON ALLEN & LUCE)

APPENDIX 6.1
Design Drawings

WASATCH REGIONAL LANDFILL FACILITY



STATE OF UTAH



PROJECT LOCATION

INDEX OF DRAWINGS

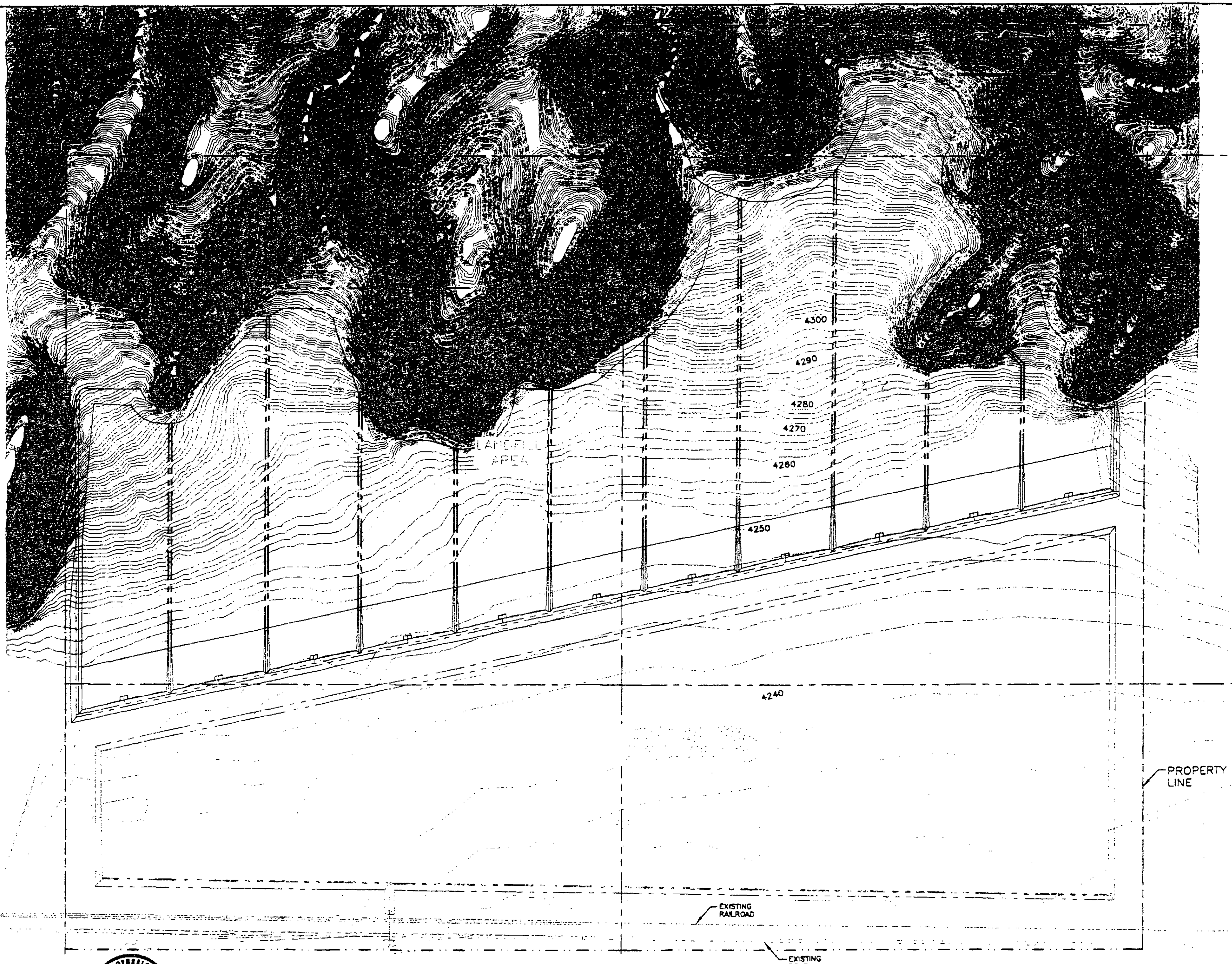
REGISTERED PROFESSIONAL ENGINEER
12-27-04
NO. 169141
KENT C. STAHELI
STATE OF UTAH

ENGINEERS:

HANSEN, ALLEN & LUCE, INC.
6771 SOUTH 900 EAST
MIDVALE, UTAH 84047
(801) 566-5599

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS
600 WEST SANDY PARK WAY
SANDY, UTAH 84070
(801) 566-6399

HANSEN ALLEN & LUCE INC	DESIGNED MPW, KCS	3	SCALE NOT TO SCALE	WASATCH REGIONAL
	DRAFTED CAH	2		WASATCH REGIONAL LANDFILL FACILITY
	CHECKED KCS	1		COVER SHEET
		REVISIONS / BY / APVD.		SHEET 1



SECTION & DETAIL IDENTIFICATION

SECTION IDENTIFICATION

SECTION CUT ON DRAWING NO. 6 AND SHOWN ON DRAWING NO. 8
ON DRAWING NO. 6 THIS SECTION IS REFERENCED AS:

2 / 8 — SECTION NUMBER; DRAWING ON WHICH SECTION APPEARS

ON DRAWING NO. 8, THIS SECTION IS IDENTIFIED AS:

SECTION 2 / 6 — SECTION NUMBER; DRAWING FROM WHICH SECTION WAS TAKEN

DETAIL IDENTIFICATION

DETAIL CALL-OUT ON DRAWING NO. 6 AND SHOWN ON DRAWING NO. 8
ON DRAWING NO. 6 THIS DETAIL IS REFERENCED AS:

B / 8 — DETAIL LETTER; DRAWING ON WHICH DETAIL APPEARS

ON DRAWING NO. 8, THIS DETAIL IS IDENTIFIED AS:

DETAIL B / 6 — DETAIL LETTER; DRAWING FROM WHICH DETAIL WAS TAKEN

NOTES:

1. IF SECTION AND DETAILS ARE SHOWN ON THE SAME DRAWING AS SECTION CUTS AND SECTION OR DETAIL CALL-OUTS DRAWING NUMBER IS REPLACED BY A LINE.
2. DETAIL LETTERS "I" AND "O" NOT USED.

TABLE OF ABBREVIATIONS

℄	CENTER LINE
CPE	CORRUGATED POLYETHYLENE
DIA.	DIAMETER
EL.	ELEVATION
FL	FLOW LINE
HDPE	HIGH DENSITY POLYETHYLENE
ID	INSIDE DIAMETER
INV EL.	INVERT ELEVATION
MAX.	MAXIMUM
MIN.	MINIMUM
N.T.S.	NOT TO SCALE
PCPE	PERFORATED CORRUGATED POLYETHYLENE PIPE
SDR	STANDARD DIMENSION RATIO
TYP.	TYPICAL

HANSEN ALLEN & LUCE INC

DESIGNED MPW, KCS	3			
DRAFTED CAH	2			
CHECKED KCS	1			
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY / APVD.

SCALE: AS SHOWN

WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

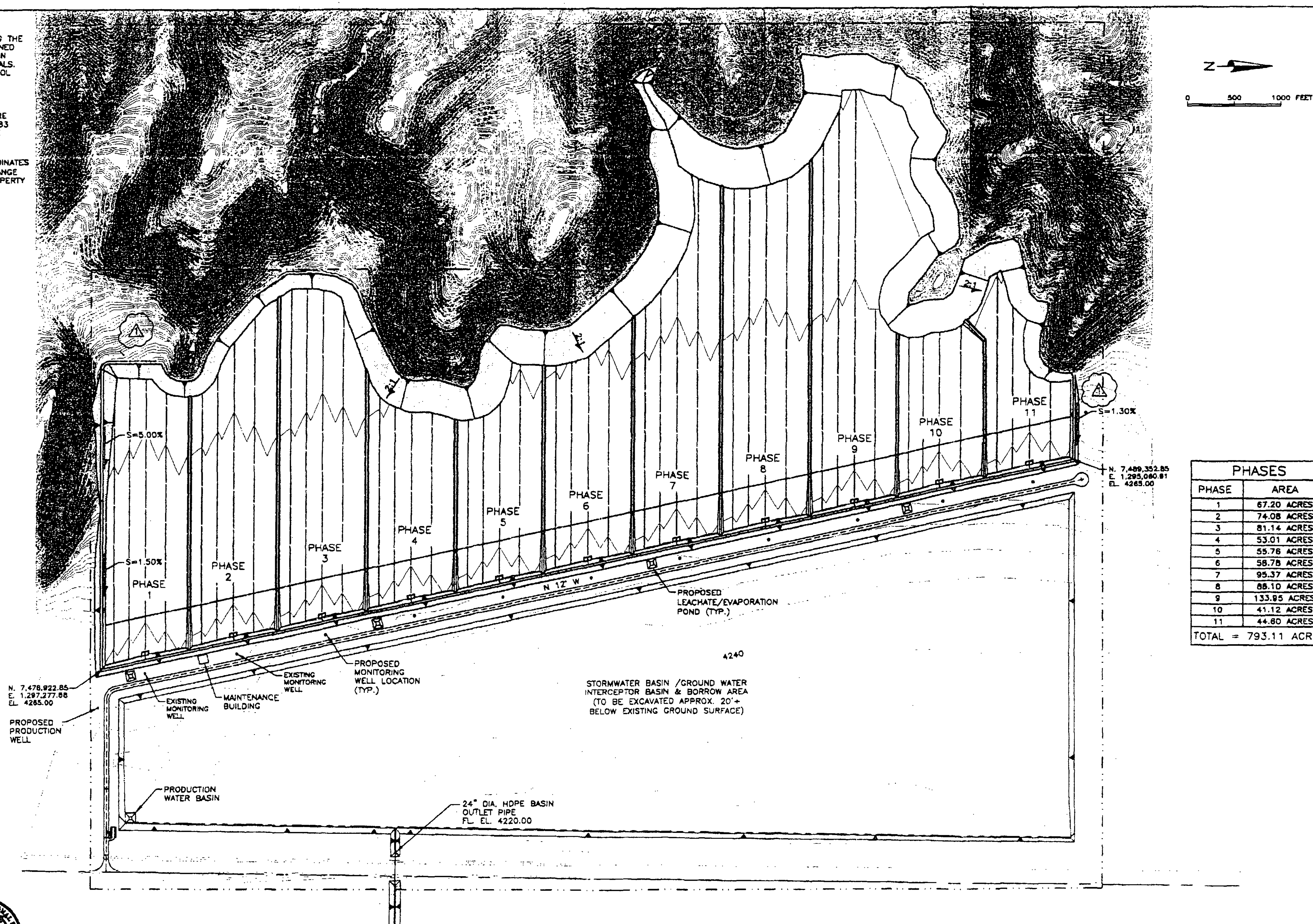
EXISTING SITE TOPOGRAPHY

SHEET 2

113-30-100

NOTES:

1. ROCK OUTCROPPING ALONG THE WEST HILLSIDE MAY BE MINED FOR RIPRAP AND OTHER ON SLOPE PROTECTIVE MATERIALS. CELL AND RUN-ON CONTROL SYSTEM DESIGN WILL BE MODIFIED AS REQUIRED TO MATCH MINED SURFACES.
2. COORDINATES PROVIDED ARE BASED ON MODIFIED NAD 83 COORDINATE SYSTEM STATE PLANE (GROUND)
3. ACTUAL LOCATIONS (COORDINATES AND ELEVATIONS) MAY CHANGE AFTER CONDUCTING A PROPERTY SURVEY AND ACCURATE TOPOGRAPHIC MAPPING.



PHASES	
PHASE	AREA
1	67.20 ACRES
2	74.08 ACRES
3	81.14 ACRES
4	53.01 ACRES
5	55.76 ACRES
6	58.78 ACRES
7	95.37 ACRES
8	88.10 ACRES
9	133.95 ACRES
10	41.12 ACRES
11	44.60 ACRES
TOTAL = 793.11 ACRES	

HANSEN ALLEN & LUCE INC

DESIGNED MPW, KCS	3					
DRAFTED CAH	2					
CHECKED KCS	1	05/2005	ADDED PROPOSED MONITORING WELL & REMOVED NOTE	CAH	KCS	
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APVD	

SCALE AS SHOWN

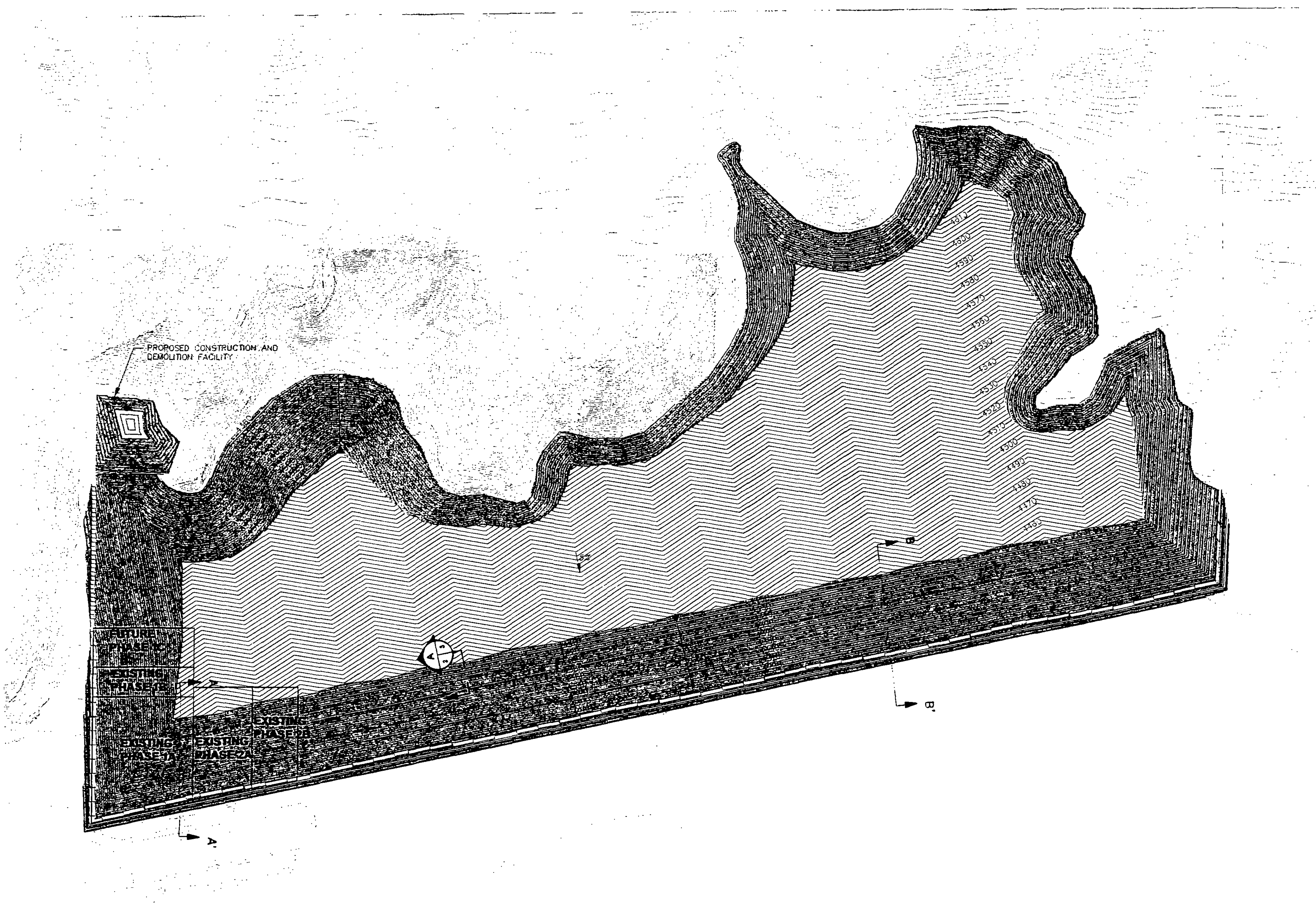
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

CELL LCRS & SUPPORT FACILITIES PLAN

SHEET 3

113-30-100



NORTH

GRAPHIC SCALE

500' 0' 250' 500' 1000'

LEGEND

	EXISTING 10 FT CONTOUR
	EXISTING 2 FT CONTOUR
1000	10 FT FINAL WASTE CONTOUR
	2 FT FINAL WASTE CONTOUR
	CONSTRUCTION AND DEMOLITION FACILITY LIMITS
	10 FT FINAL TOE DRAINAGE BERM CONTOUR
	2 FT FINAL TOE DRAINAGE BERM CONTOUR

QUANTITIES

LANDFILL AIRSPACE = 223,240,000 CY
C&D AIRSPACE = 779,524 CY
LANDFILL AREA = 733 ACRES
C&D AREA = 11.2 ACRES

NOTES:
1. EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY PERFORMED BY OLYMPUS AERIAL SURVEYS, INC ON MARCH 3, 2008

REV. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
A	10/14/09	ISSUED FOR PERMITTING	RPB	JVR	JVR	JVR

DATE OF ISSUE: 10/14/2009
DESIGNED BY: JVR
DRAWN BY: RPB
CHECKED BY: JVR
APPROVED BY: JVR

VECTOR ENGINEERING, INC.
An Ausenco group company
THE AMERICAS • ASIA • AUSTRALIA
143E Spring Hill Drive, Grass Valley, CA 95945 +1-530-272-2448 +1-530-272-8533 fax

WASATCH REGIONAL LANDFILL, INC.

WASATCH REGIONAL LANDFILL
PERMIT RENEWAL
TOOELE COUNTY, UTAH

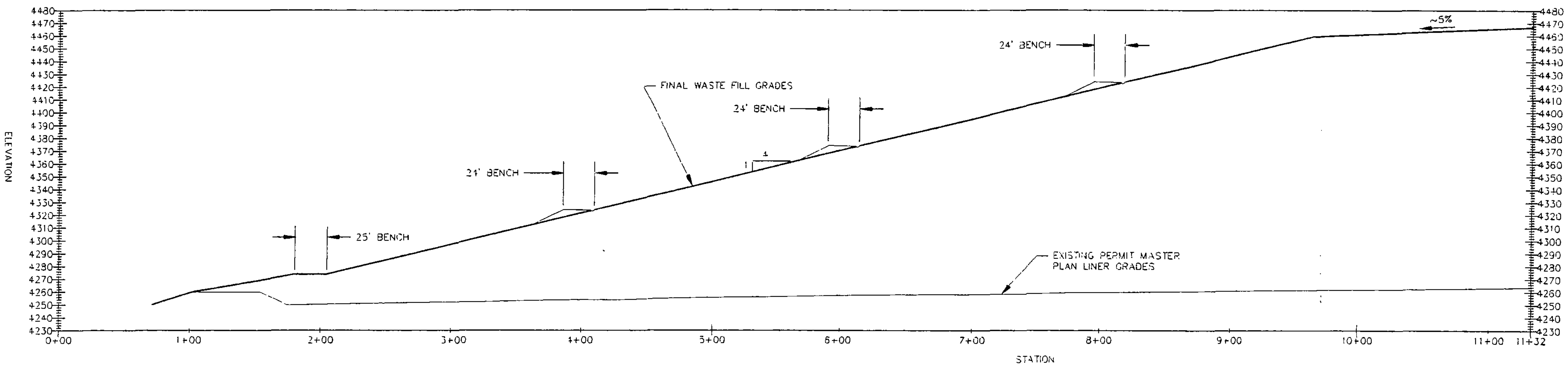
FINAL WASTE GRADE

FIGURE NO 2

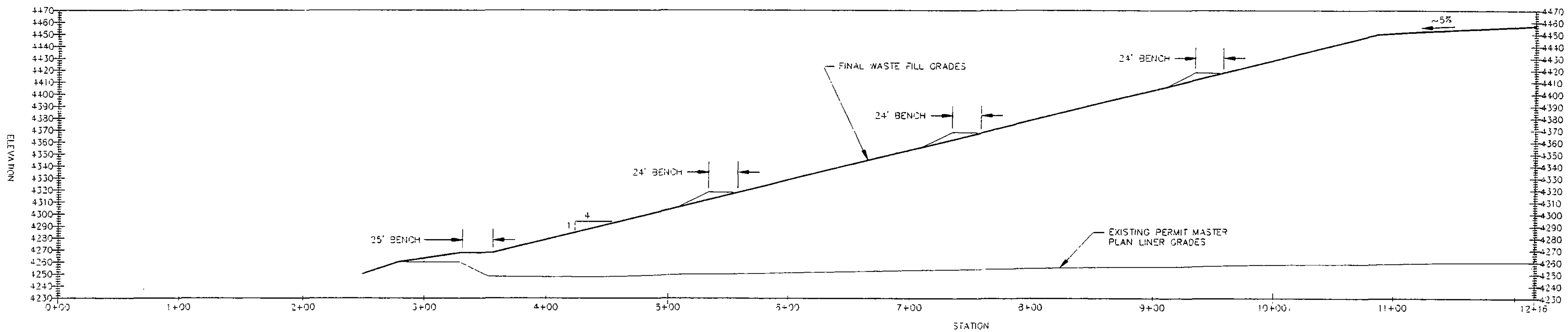
PROJECT NO 061204.13

ISSUED FOR PERMITTING

Replaces sheet 4



SECTION A-A' 2 4
1" = 50'



SECTION B-B' 2 4
1" = 50'

REV. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
A	10/14/09	ISSUED FOR PERMITTING	RPB	JVR	JVR	JVR

DATE OF ISSUE: 10/14/2009
DESIGNED BY: JVR
DRAWN BY: RPB
CHECKED BY: JVR
APPROVED BY: JVR

VECTOR ENGINEERING, INC.
An Ausenco group company
THE AMERICAS • ASIA • AUSTRALIA
143E Spring Hill Drive, Grass Valley, CA 95945 +1-530-272-2448 +1-530-272-8533 fax

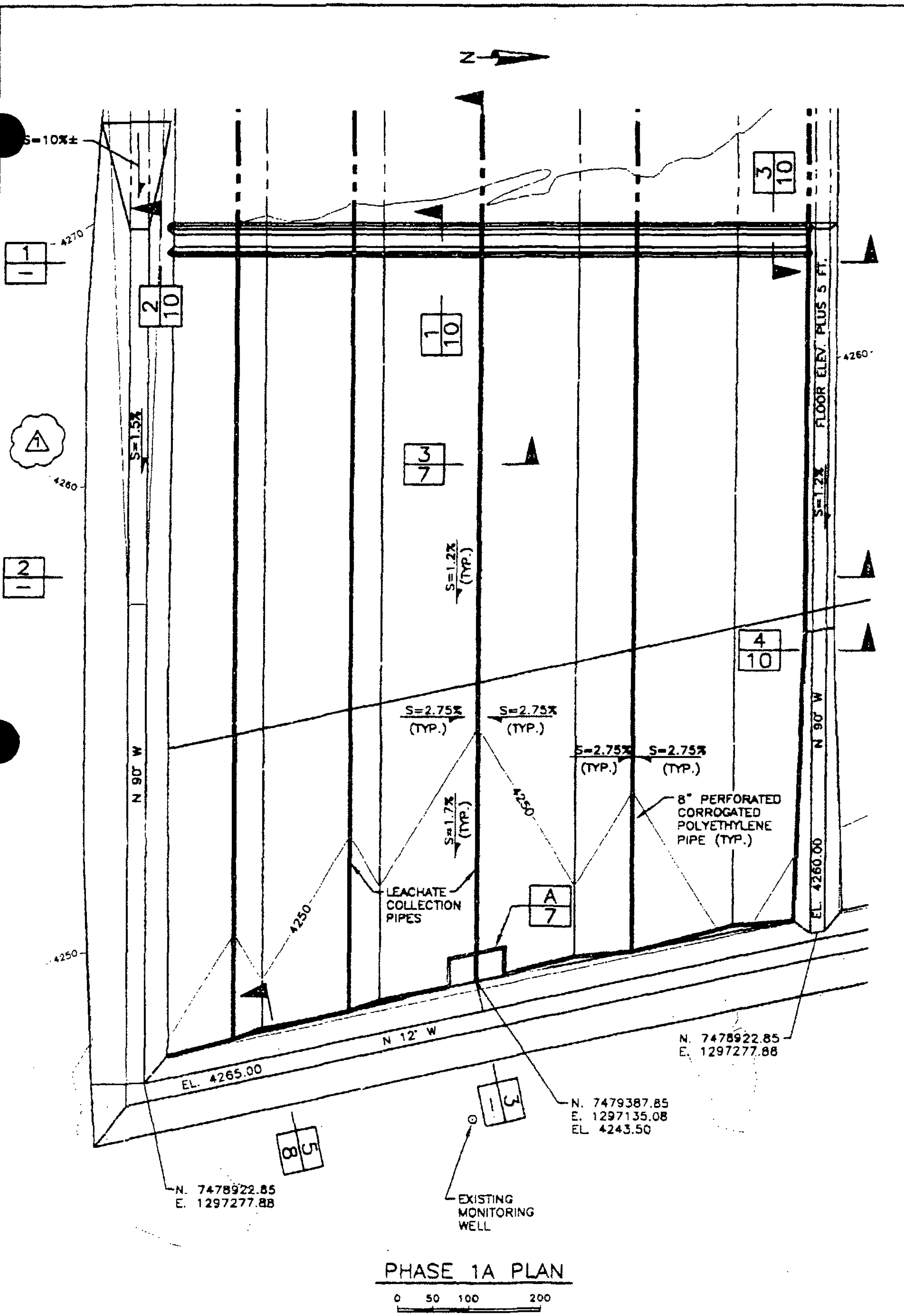
WASATCH REGIONAL LANDFILL, INC.

WASATCH REGIONAL LANDFILL
PERMIT
RENEWAL
TOOELE COUNTY, UTAH
CROSS SECTIONS

FIGURE NO. 4
PROJECT NO. 061204.13

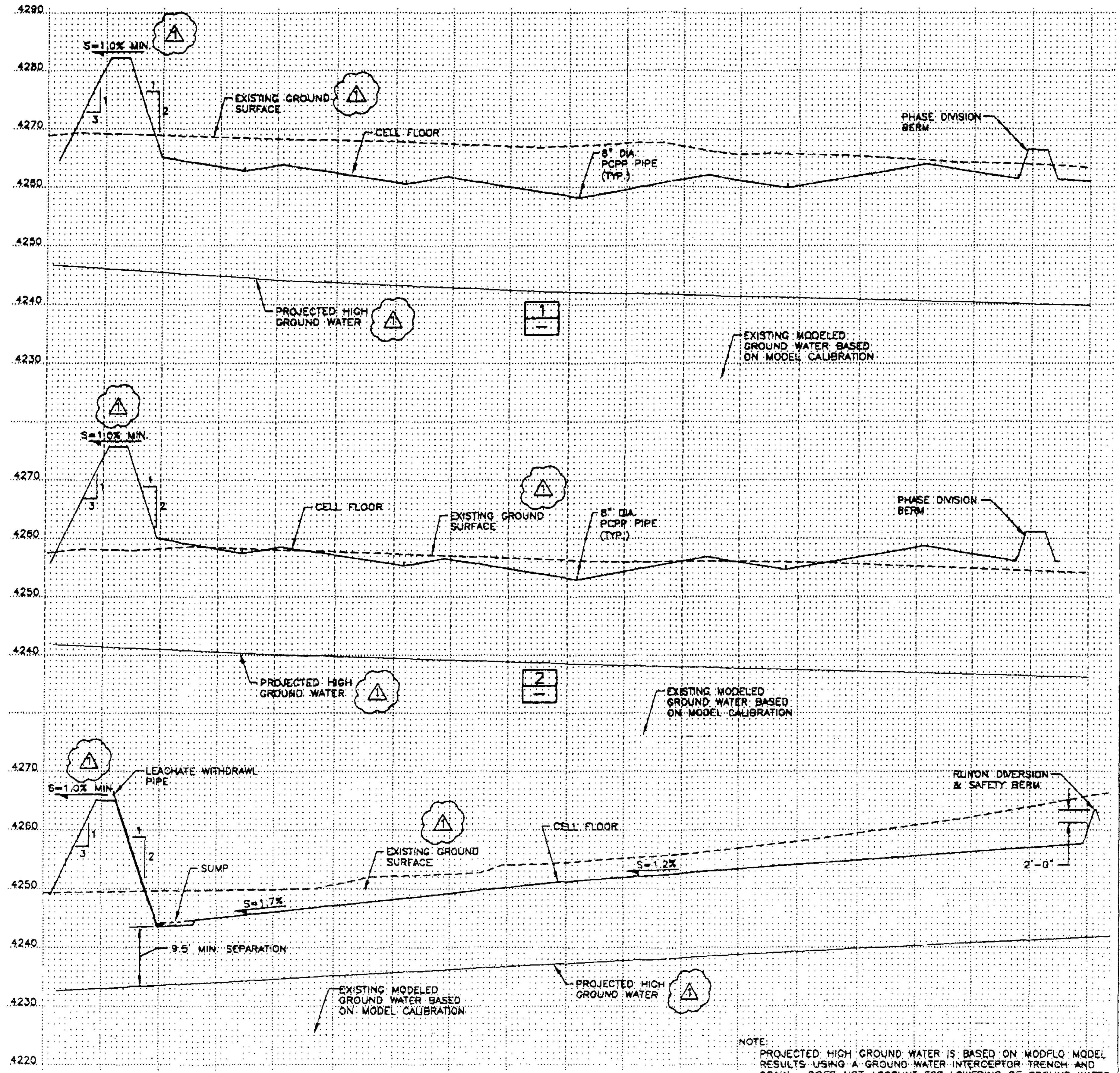
ISSUED FOR PERMITTING

Replaces Sheet 5



PHASE 1A PLAN

0 50 100 200



NOTE:
PROJECTED HIGH GROUND WATER IS BASED ON MODFLO MODEL RESULTS USING A GROUND WATER INTERCEPTOR TRENCH AND DRAIN. DOES NOT ACCOUNT FOR LOWERING OF GROUND WATER LEVELS FOR COMPLETE BORROW EXCAVATION.

TYPICAL CELL SECTIONS 3

HORIZONTAL 1" = 120'
VERTICAL 1" = 40'

DESIGNED MPW, KCS	3				
DRAFTED DRB	2				
CHECKED KCS	1	05/2005	ADDED SLOPE CALLOUTS, NEW CONTOURS, MODIFIES EXISTING GROUND SURFACE & PROJECTED HIGH WATER	CAH	KCS
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APPD

HANSEN ALLEN & LUCE INC

SCALE: AS SHOWN

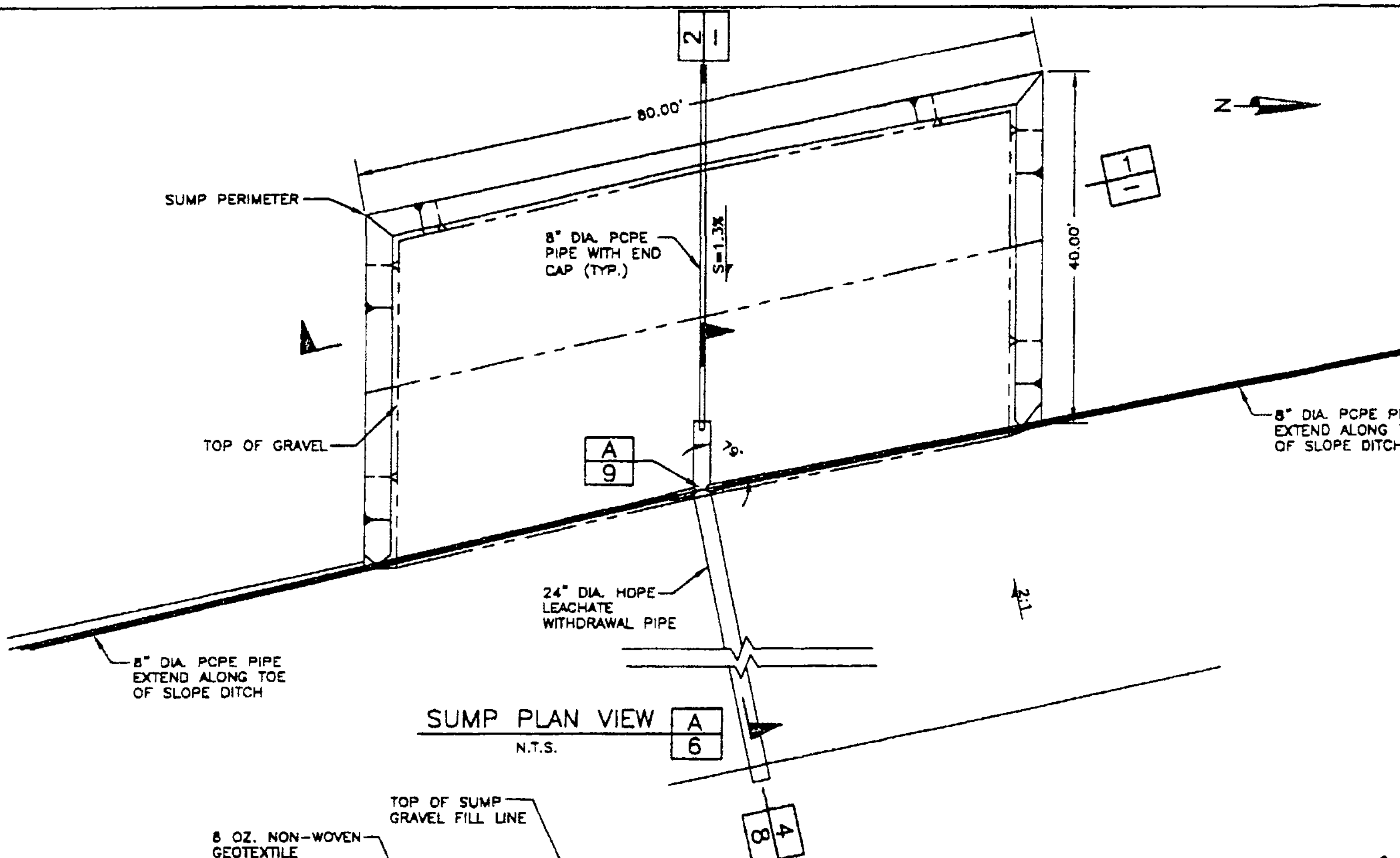
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

PHASE 1A PLAN & SECTIONS

SHEET 6

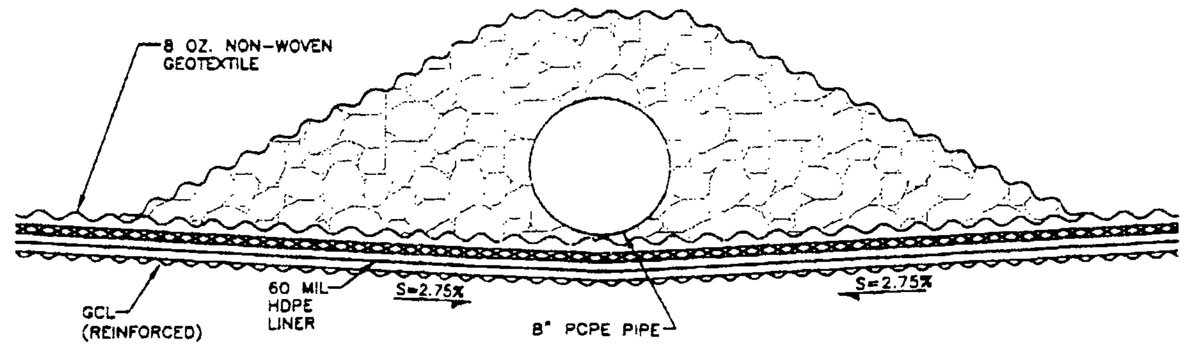
113-30-100



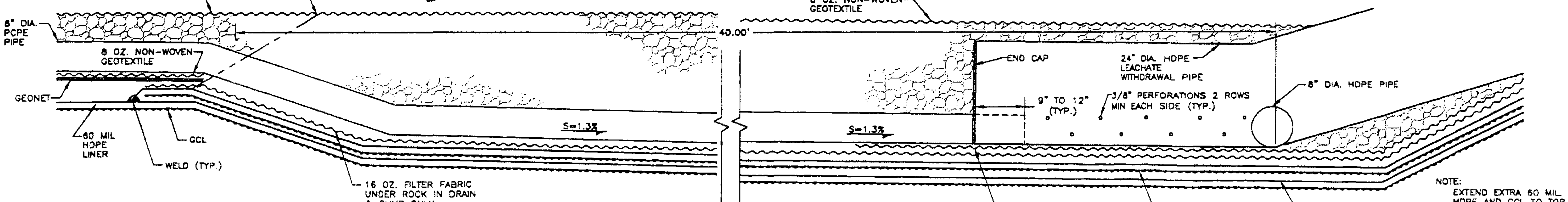
SUMP PLAN VIEW A/6
N.T.S.

NOTES:

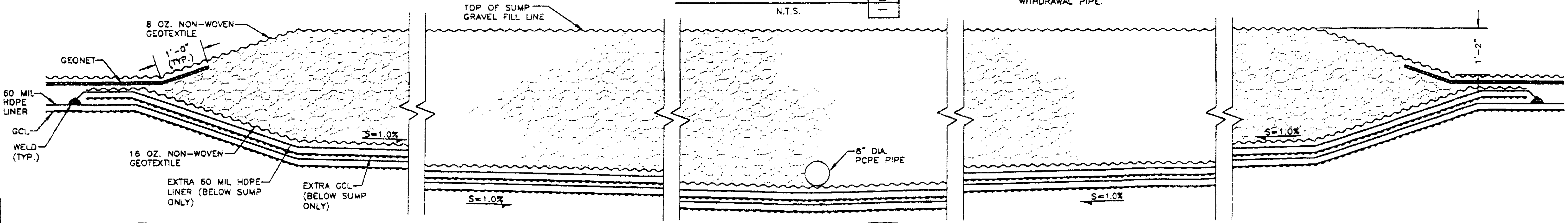
1. FILL ENTIRE SUMP AND TOE OF SLOPE DITCHES WITH 1 1/2" MINUS WASHED ROCK TO TOP OF SUMP GRAVEL FILL LINE.
2. PCPE REFERS TO PERFORATED CORRUGATED POLYETHYLENE PIPE



LEACHATE CONVEYANCE PIPE TYP. SECTION 3/6
N.T.S.

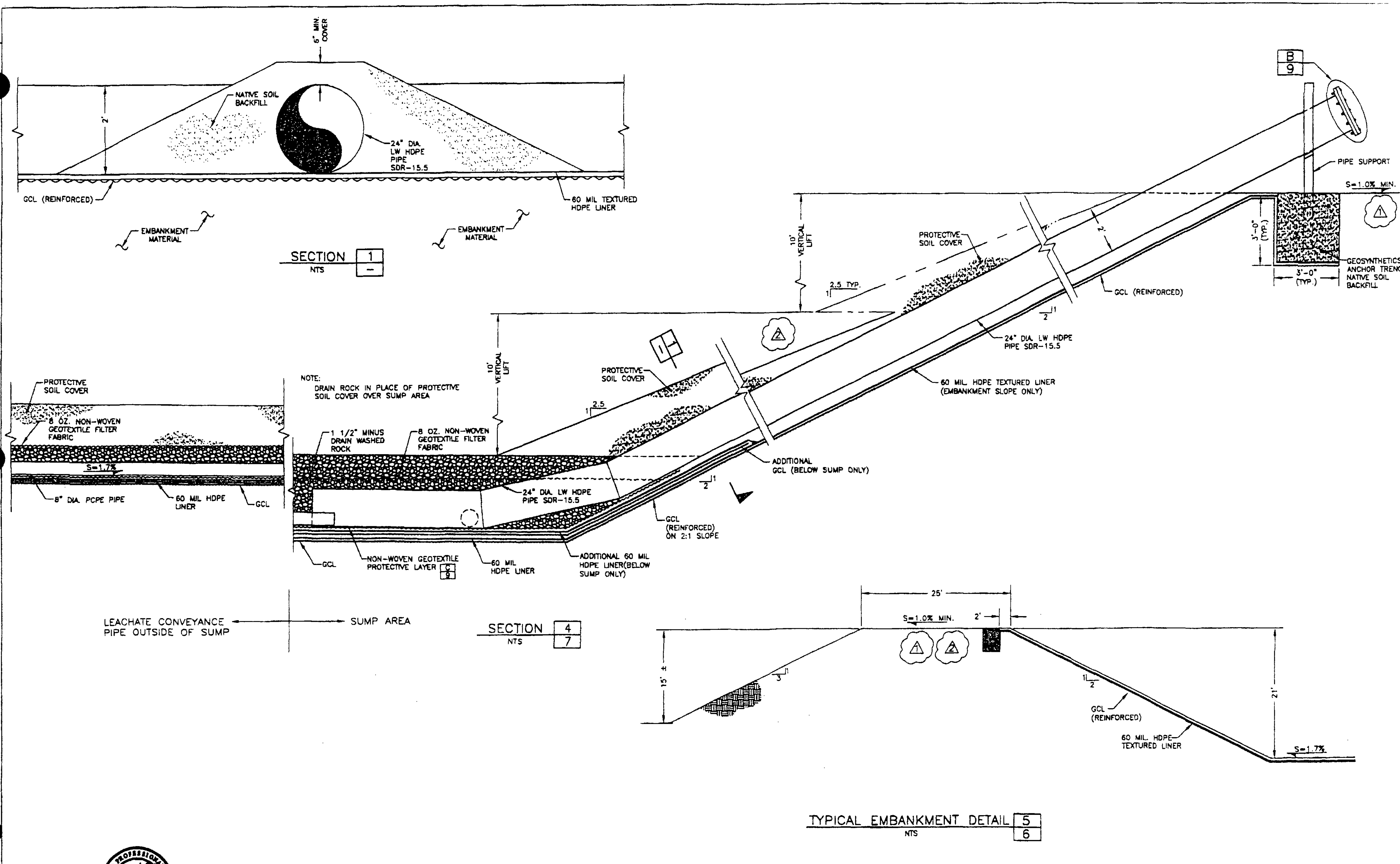


SUMP CROSS SECTION 2/—
N.T.S.



SUMP CROSS SECTION 1/—
N.T.S.

HANSEN ALLEN & LUCE INC ENGINEERS	DESIGNED MPW, KCS	3		SCALE 1" = 10'	WASATCH REGIONAL LANDFILL FACILITY
PROJECT ENGINEER	DRAFTED SDM	2			SUMP PLAN & SECTIONS
	CHECKED KCS	1			SHEET 7
	DATE DECEMBER 2004	NO.	DATE / REVISIONS / BY / APVD.	WASATCH REGIONAL	113-30-100



DESIGNED MPW, KCS	3					
DRAFTED SDM	2	08/2005	CHANGED SLOPE DIRECTION & MODIFIED VIEW ON SECTION TO ILLUSTRATE LIFT HEIGHT	CAH	KCS
CHECKED KCS	1	05/2005	REMOVED ROAD BASE & ADDED SLOPE CALLOUT	CAH	KCS
	NO.	DATE	REVISIONS	BY	APVD.

SCALE: AS SHOWN

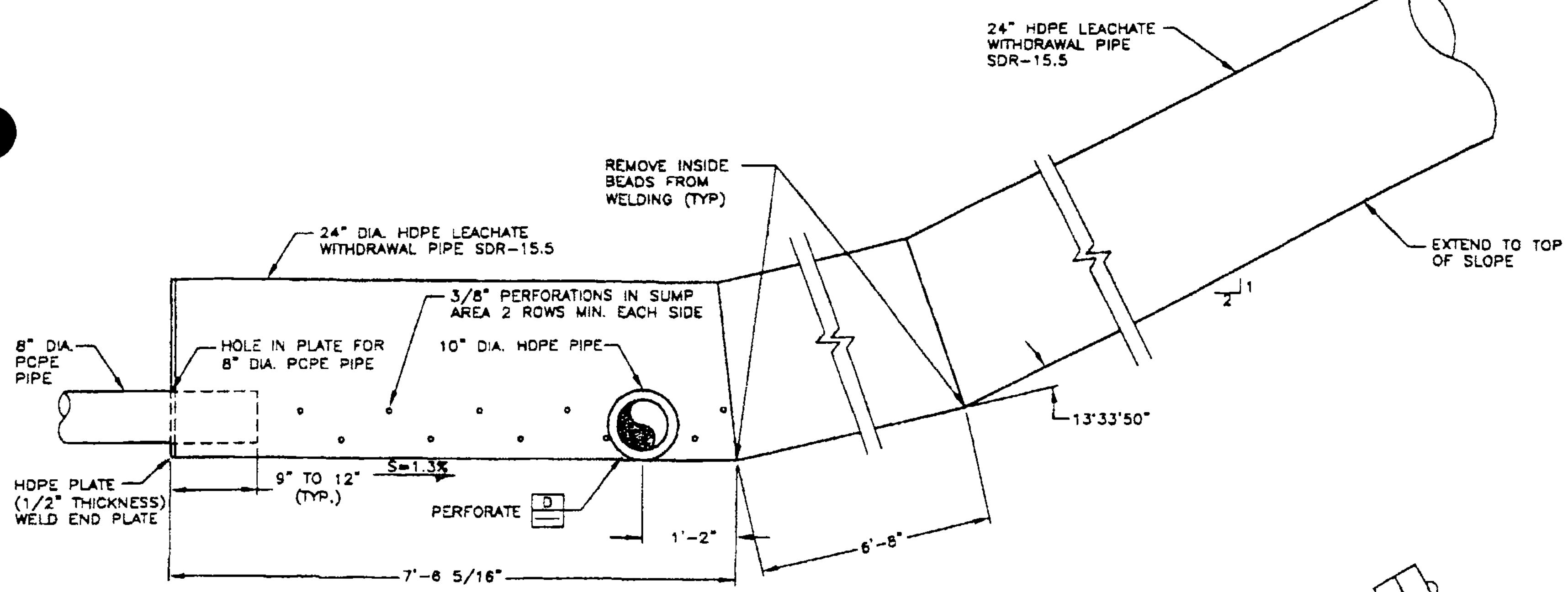
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

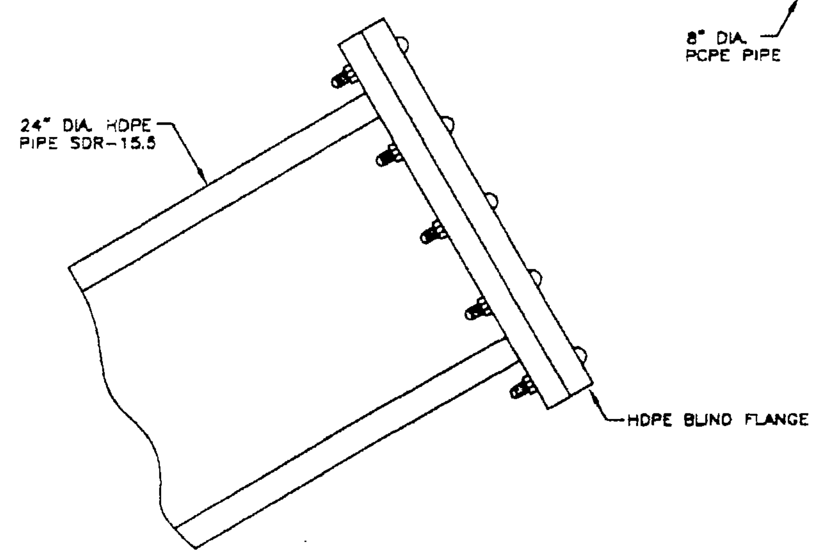
LEACHATE WITHDRAWAL PIPE SECTIONS

SHEET 8

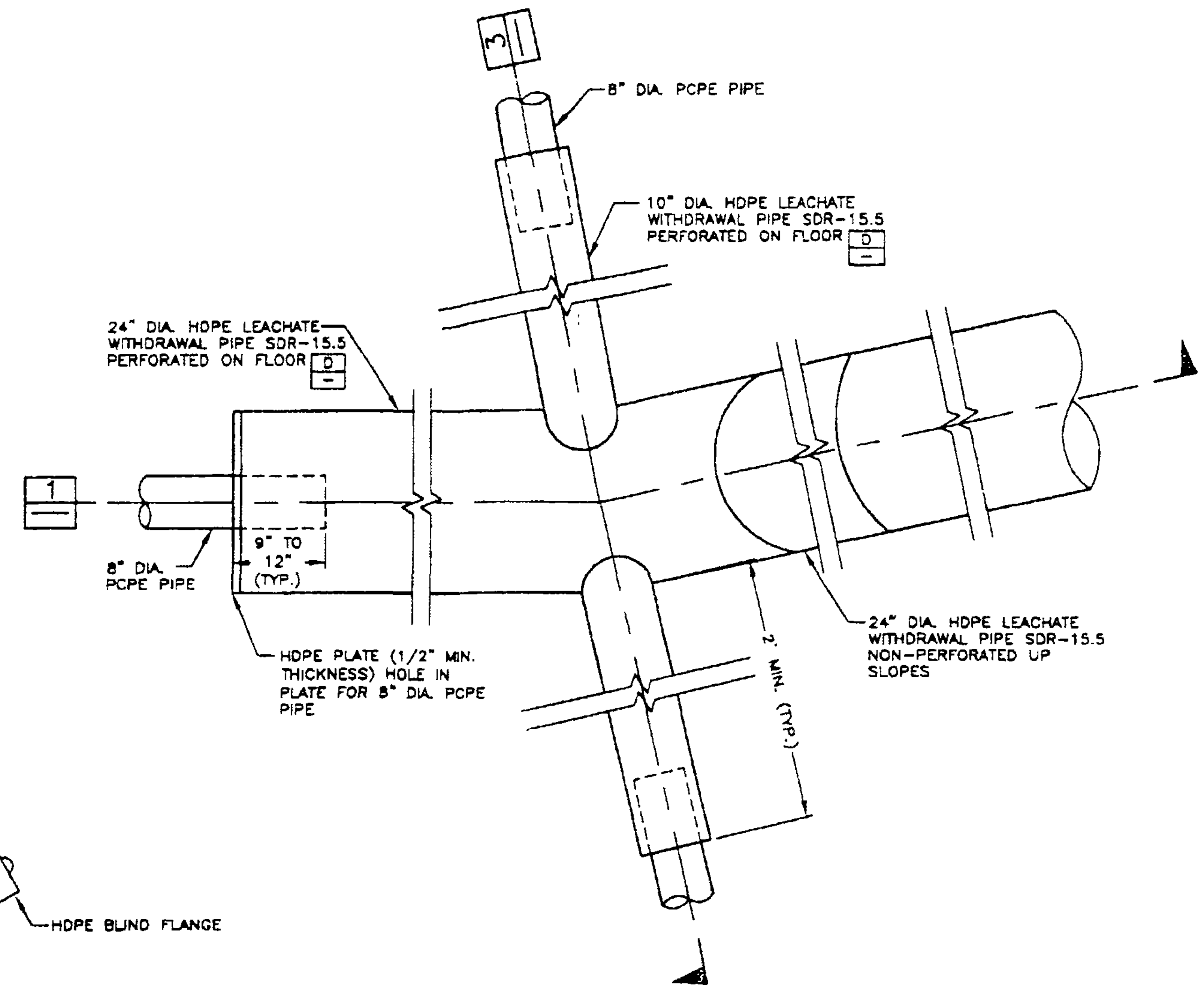
113-30-100



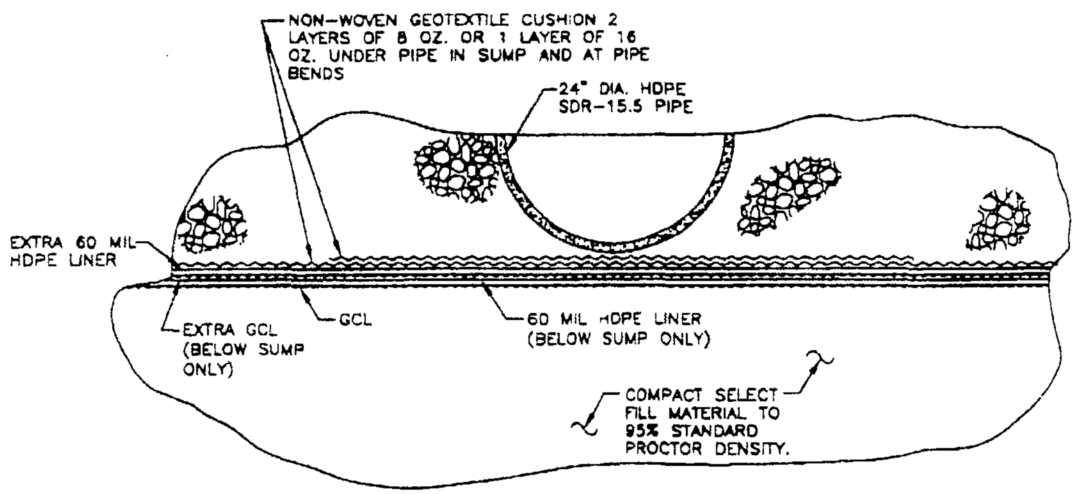
LEACHATE WITHDRAWAL PIPE SECTION 1
N.T.S.



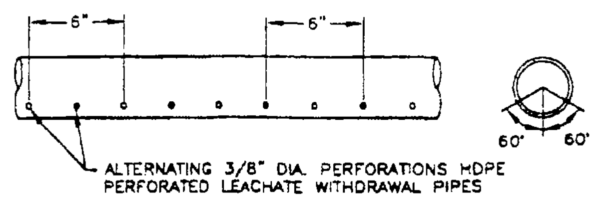
24" DIA. HDPE CAP DETAILS B 8
N.T.S.



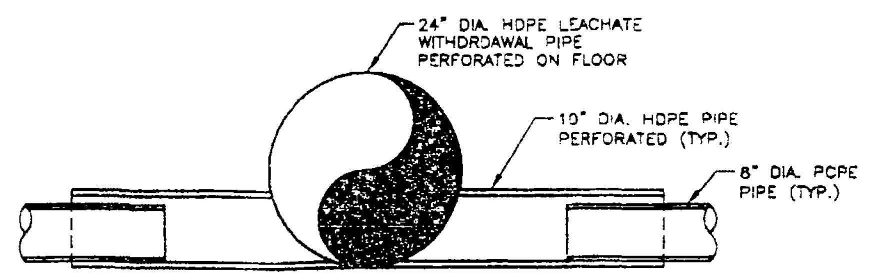
LEACHATE WITHDRAWAL PIPE DETAIL A 7
N.T.S.



DETAIL C 8
4" = 1'-0"



PERFORATION DETAIL D
N.T.S.



CROSS SECTION 3
N.T.S.

HANSEN ALLEN & LUCE INC

DESIGNED MPW, KCS	3				
DRAFTED CAH	2				
CHECKED KCS	1				
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APVD.

SCALE AS SHOWN

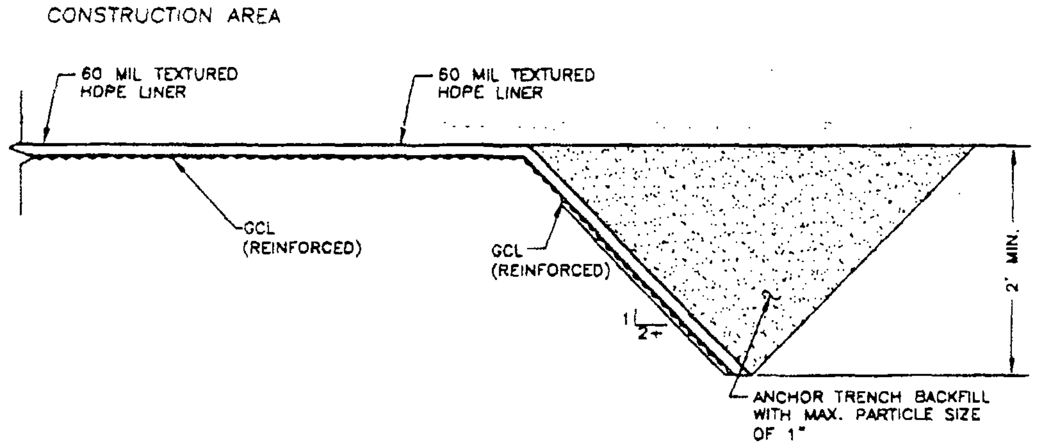
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

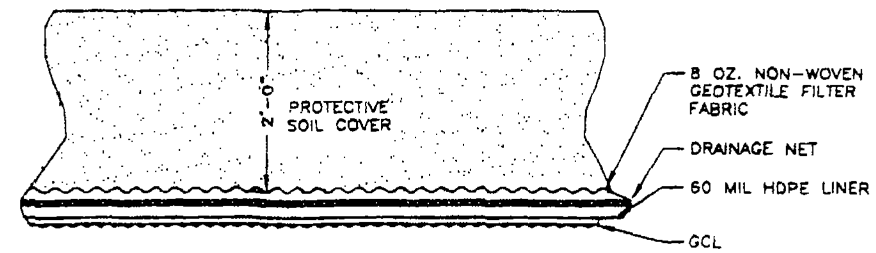
LEACHATE WITHDRAWAL SYSTEM DETAILS

SHEET 9

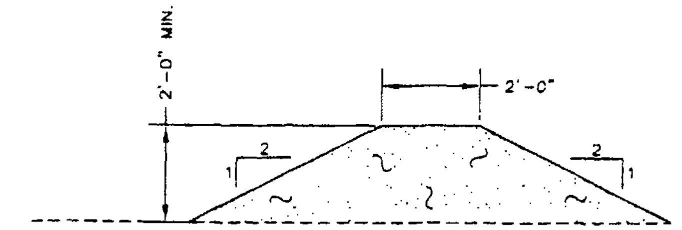
113-30-100



TYPICAL SIDE SLOPE GEOSYNTHETIC TIE-IN DETAIL 2/6
N.T.S.



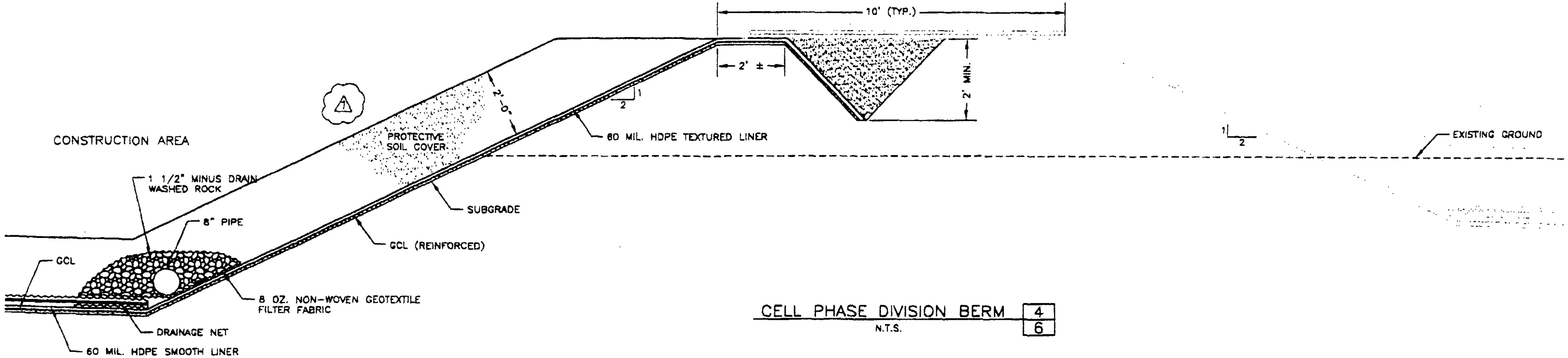
TYPICAL CELL FLOOR LINER SYSTEM SECTION B/–
N.T.S.



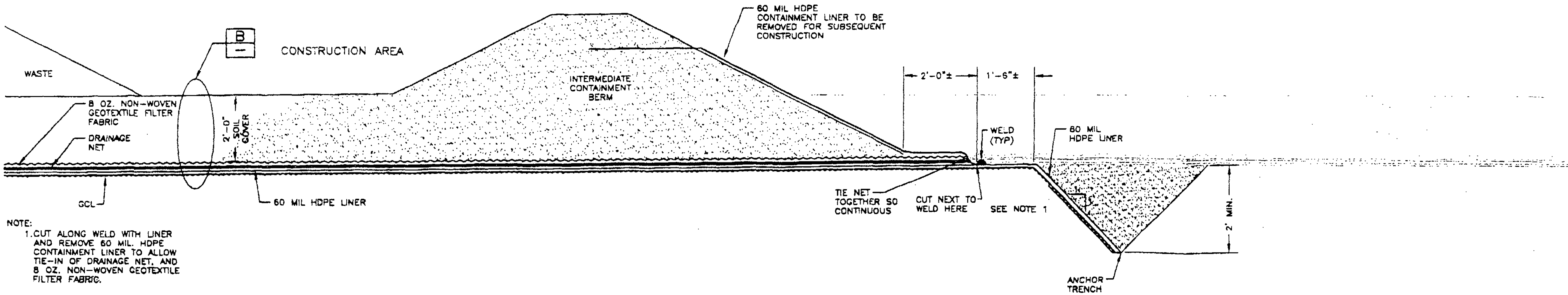
NOTES:

1. THE RUN-ON DIVERSION/SAFETY BERM IS TO BE CONSTRUCTED AROUND THE TOP PERIMETER OF CELL EXCAVATIONS WHERE NO RAISED EMBANKMENTS ARE CONSTRUCTED.
2. OWNER MAY DIRECT CONSTRUCTION OF A DITCH IN PLACE OF THE BERM.

TYPICAL RUN-ON DIVERSION/SAFETY BERM DETAIL 3/6
N.T.S.



CELL PHASE DIVISION BERM 4/6
N.T.S.



NOTE:
1. CUT ALONG WELD WITH LINER AND REMOVE 60 MIL. HDPE CONTAINMENT LINER TO ALLOW TIE-IN OF DRAINAGE NET, AND 8 OZ. NON-WOVEN GEOTEXTILE FILTER FABRIC.

TYPICAL INTERMEDIATE CONTAINMENT BERM SECTION 1/6
N.T.S.

FILE NAME: ...30.100\CADFILES\PERMIT DWGS\PHASEBERMDETAILS__R1.DWG
FILE DATE: ...2005 08:28:08 (CAH)

HANSEN ALLEN & LUCE INC

DESIGNED MPW, KCS	3				
DRAFTED JDB	2				
CHECKED KCS	1	06/2005	ADDED 2'-0" SOIL COVER TO CELL PAHSE DIVISION BERM	CAH	KCS
			REVISIONS	BY	APVD.

SCALE: AS SHOWN

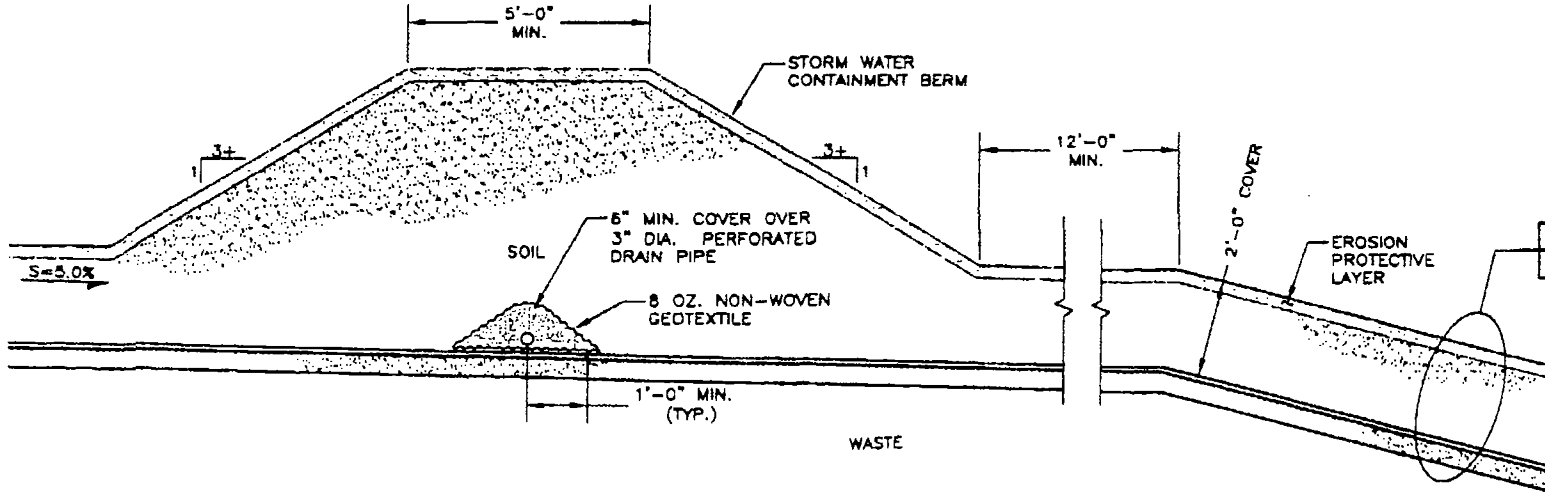
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

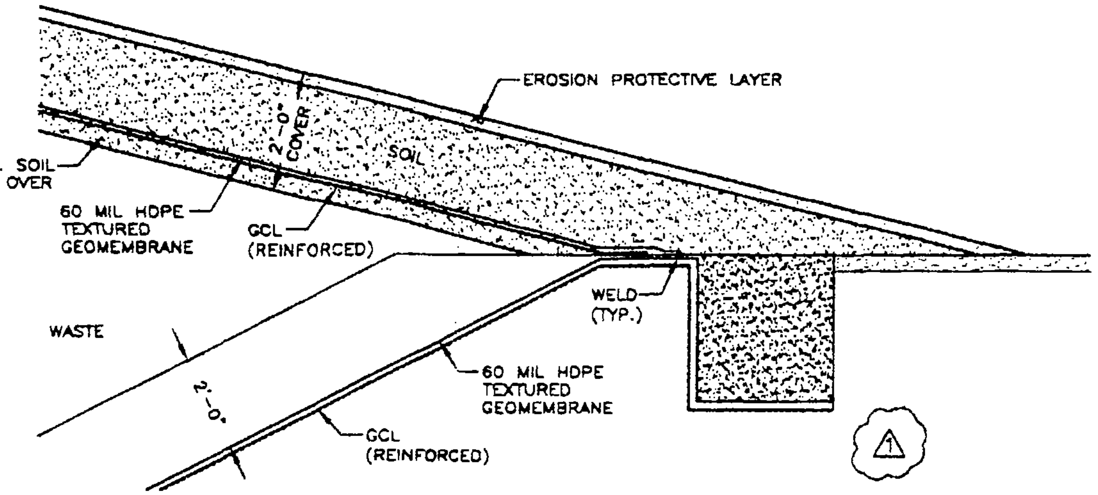
TYPICAL LINER SYSTEM SECTIONS & DETAILS

SHEET 10

113-30-100



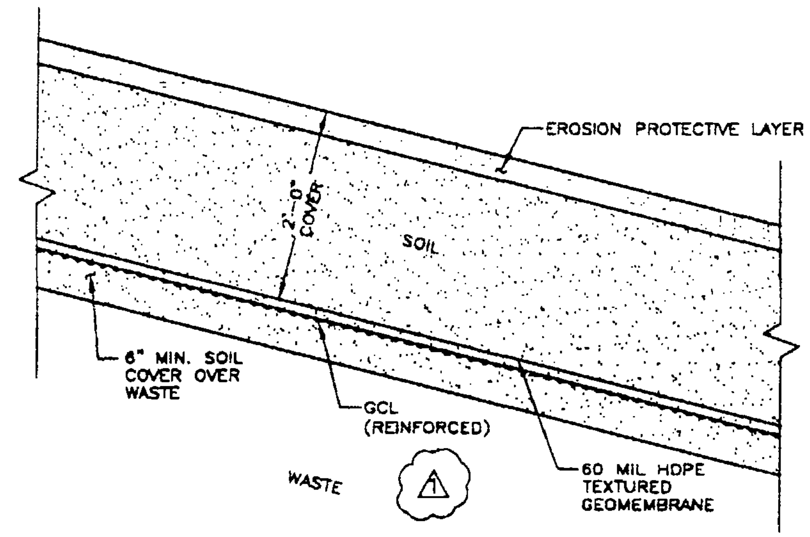
TOP OF 4:1 SLOPE SECTION 6/4
N.T.S.



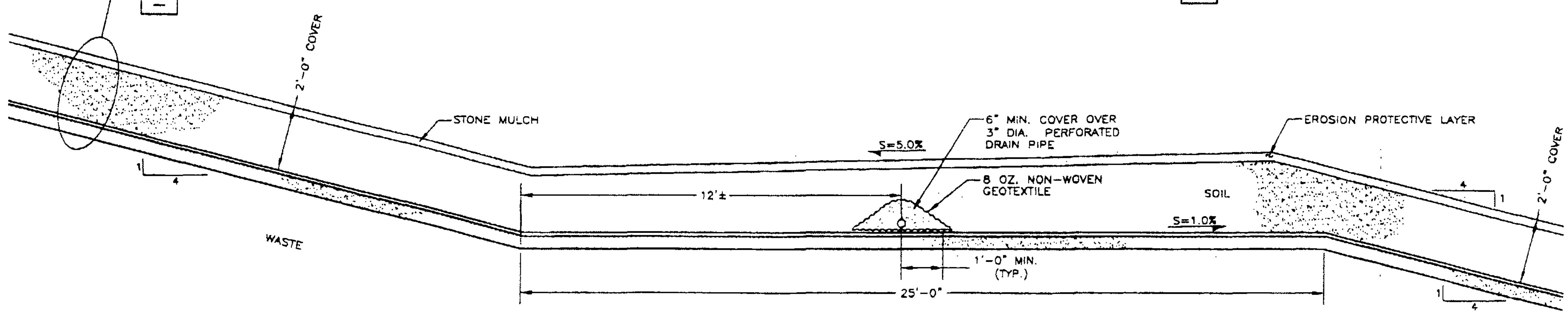
CAP TO CELL LINER TIE IN 8/4
N.T.S.

NOTES:

1. DRAIN PIPES UNDER STORM WATER CONTAINMENT BERMS AND UNDER BENCH DRAINAGE CHANNELS TO TIE INTO DOWN SPOUT INLET BOXES.
2. EROSION PROTECTION LAYER TO BE 3 INCHES THICK IF USING STONE MULCH OR 6 INCHES OF TOP SOIL WITH VEGETATION.



TYPICAL CLOSURE CAP LAYER DETAIL A/–
N.T.S.



TYPICAL CLOSURE CAP BENCH DRAINAGE CHANNEL SECTION 7/4
N.T.S.

HANSEN ALLEN & LUCE INC

PROJECT ENGINEER

DESIGNED MPW, KCS	3				
DRAFTED CAH	2				
CHECKED KCS	1	05/2005	ADDED CAP TO CELL LINER TIE IN DETAIL & GCL	CAH	KCS
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APVD.

SCALE: AS SHOWN

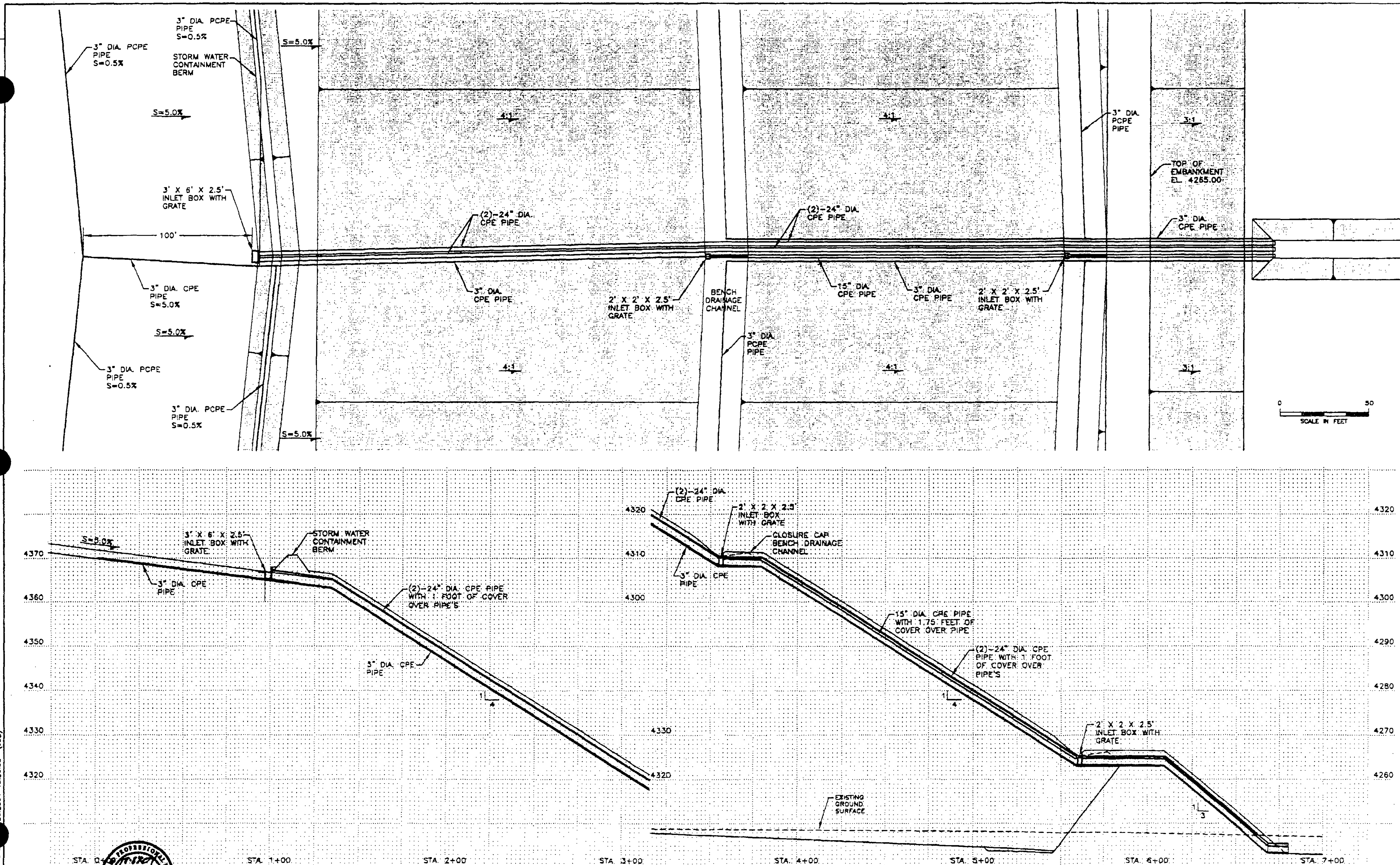
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

CLOSURE CAP DETAILS

SHEET 11

113-30-100



HANSEN ALLEN & LUCE INC ENGINEERS	DESIGNED MPW, KCS	3
PROJECT ENGINEER	DRAFTED DRB	2
	CHECKED KCS	1
	DATE DECEMBER 2004	NO. DATE REVISIONS BY APVD.

SCALE AS SHOWN

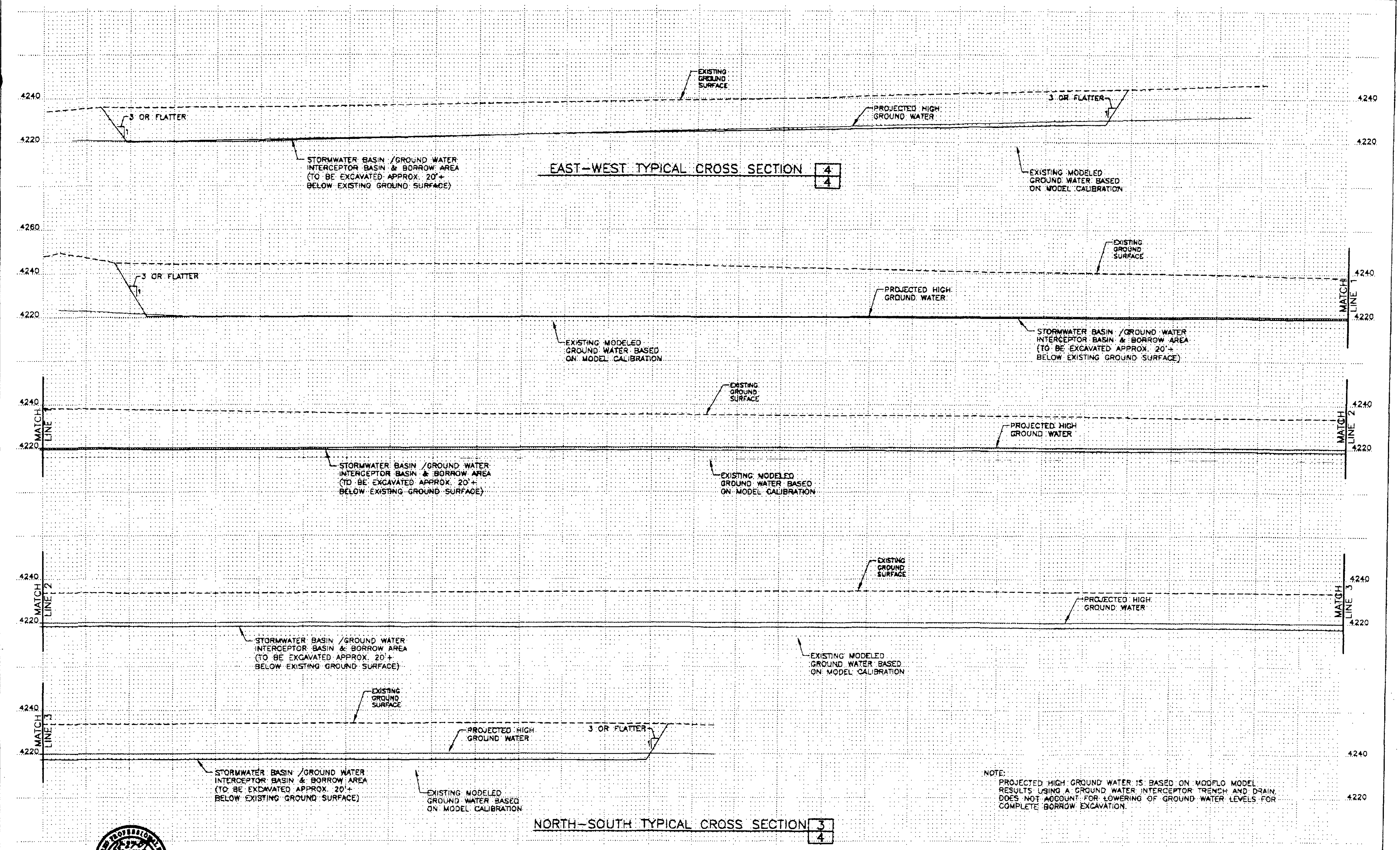
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

DOWNSPOUT PLAN & PROFILE

SHEET 12

113-30-100



NOTE:
PROJECTED HIGH GROUND WATER IS BASED ON MODFLO MODEL RESULTS USING A GROUND WATER INTERCEPTOR TRENCH AND DRAIN. DOES NOT ACCOUNT FOR LOWERING OF GROUND WATER LEVELS FOR COMPLETE BORROW EXCAVATION.

FILE 113\30.100\CADFILES\PERMIT DWGS\BASIN SECTIONS.DWG
FILE DATE 12.20.2004 12:10:30 (DRB)

HANSEN ALLEN & LUCE inc ENGINEERS

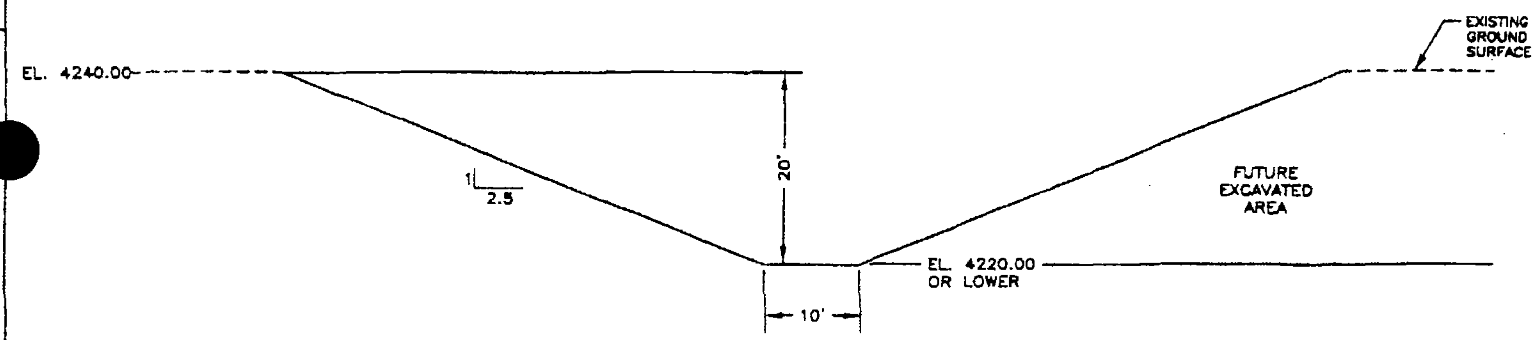
DESIGNED MPW, KCS	3				SCALE HORIZONTAL 1" = 200' VERTICAL 1" = 40'	
DRAFTED DRB	2					
CHECKED KCS	1					
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY APVD.		

PROJECT ENGINEER

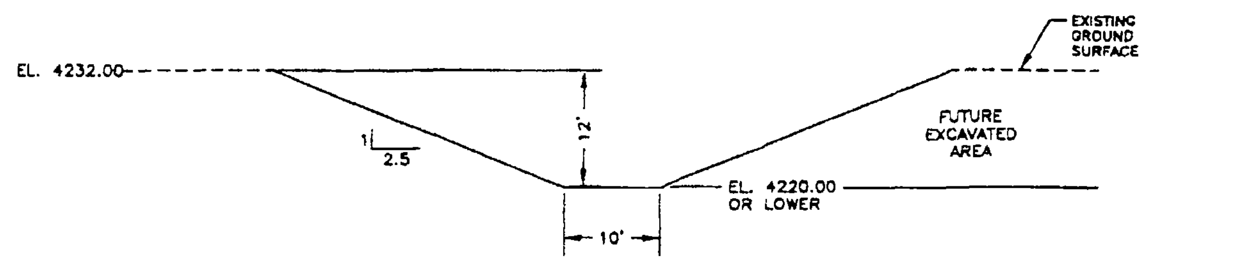
WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY
GROUND WATER INTERCEPTOR &
STORM WATER BASIN SECTIONS

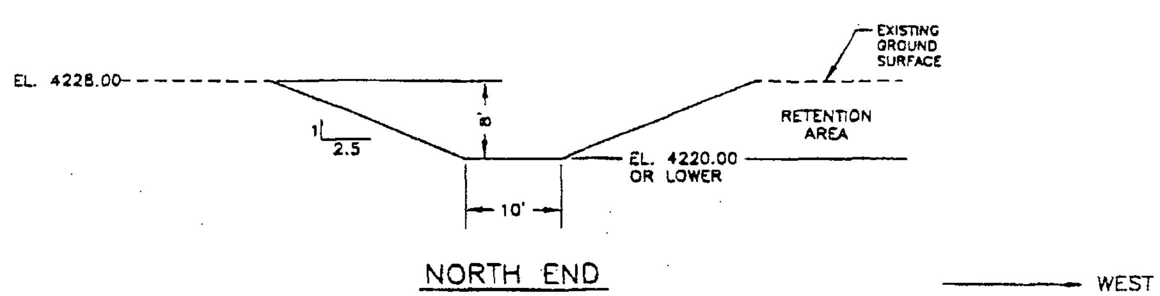
SHEET 13
113-30-100



SOUTH END

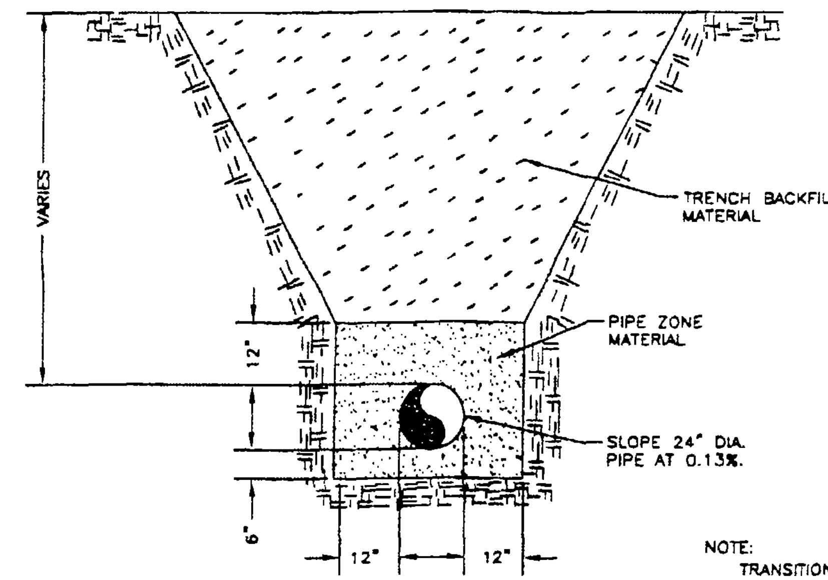


MIDDLE



NORTH END

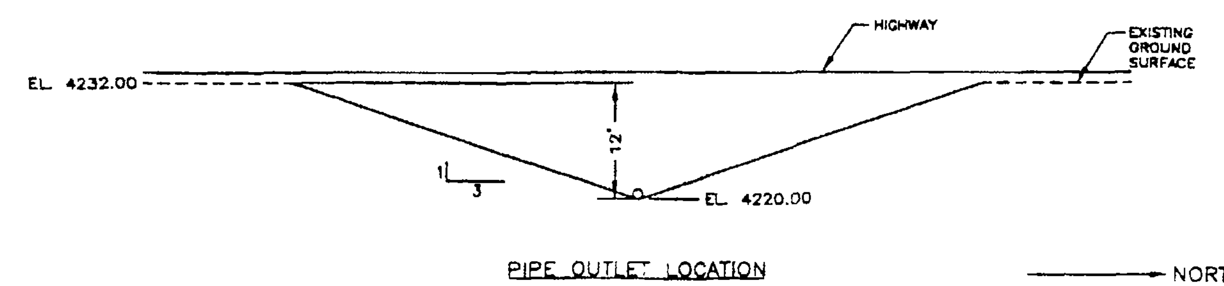
DRAIN TRENCH TYPICAL CROSS SECTIONS A/4



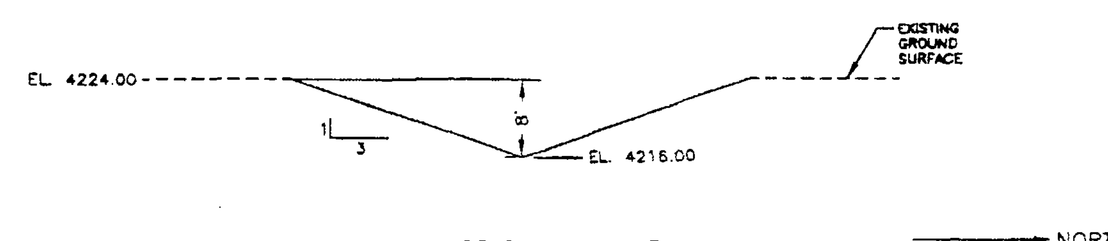
TYPICAL TRENCH SECTION

NOTE:
TRANSITION FROM TRENCH TO DITCH WHEN COVER OVER PIPE IS 3 FEET. SEE TYPICAL CROSS SECTION BELOW FOR DITCH.

DRAIN TRENCH OUTLET PIPE B/4

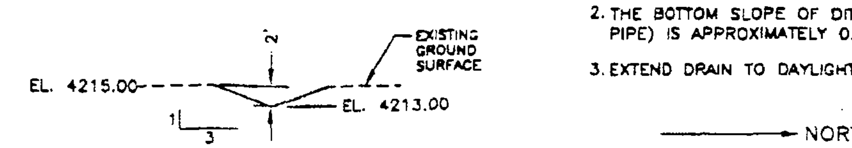


PIPE OUTLET LOCATION



NEAR MIDDLE OF CHANNEL

NOTES:
1. THE OUTLET DITCH MAY BE REPLACED WITH 24" DIA. PIPE.
2. THE BOTTOM SLOPE OF DITCH (OR PIPE) IS APPROXIMATELY 0.1 %.
3. EXTEND DRAIN TO DAYLIGHT.



TO DAYLIGHT

DRAIN TRENCH OUTLET C/4

HANSEN ALLEN & LUCE INC ENGINEERS	PROJECT ENGINEER	DESIGNED MPW, KCS	3		
		DRAFTED CAH	2		
		CHECKED KCS	1		
		DATE DECEMBER 2004	NO.	DATE	REVISIONS BY APVD.

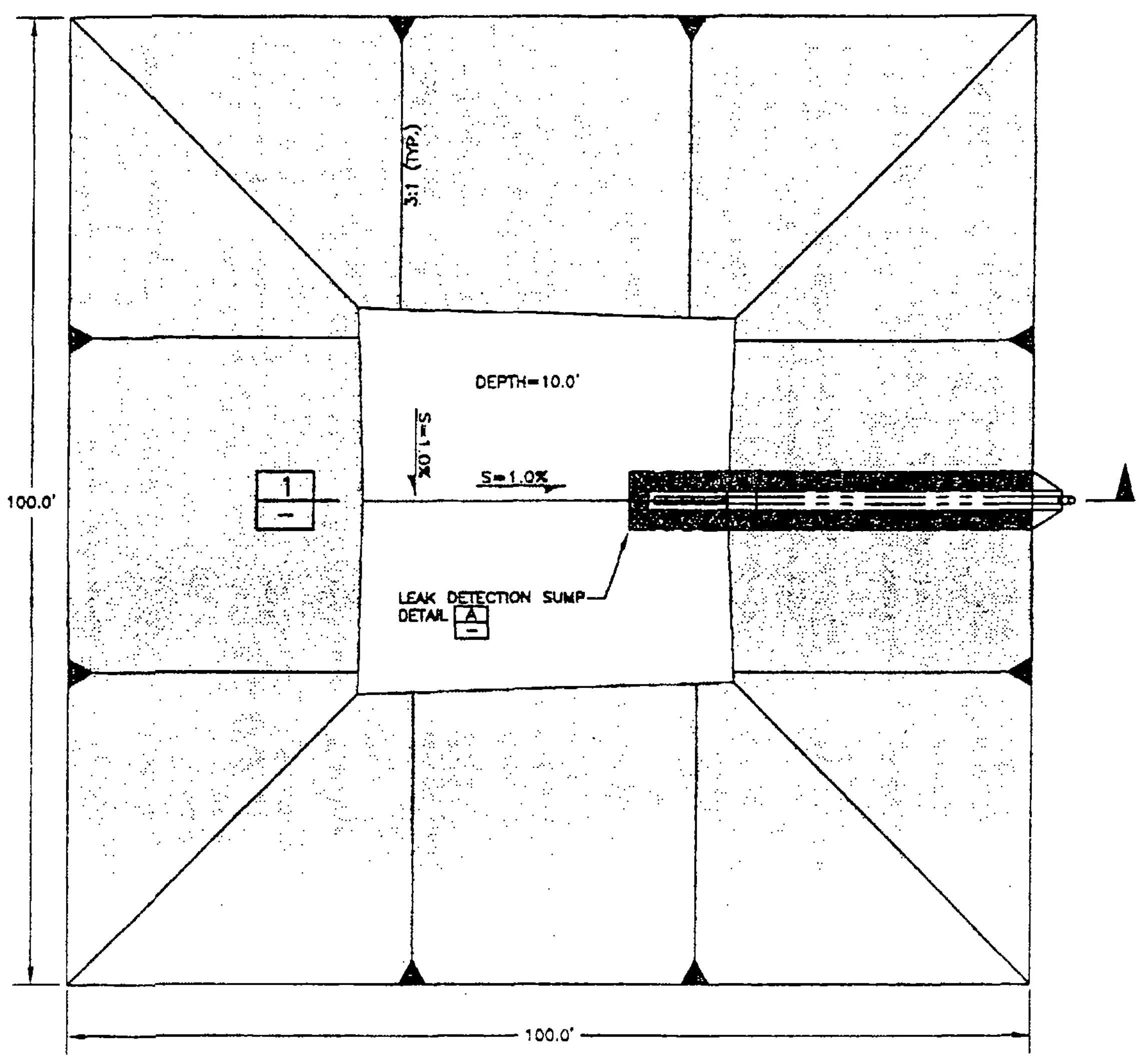
SCALE

WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY
GROUND WATER INTERCEPTOR &
STORM WATER BASIN OUTLET SECTIONS

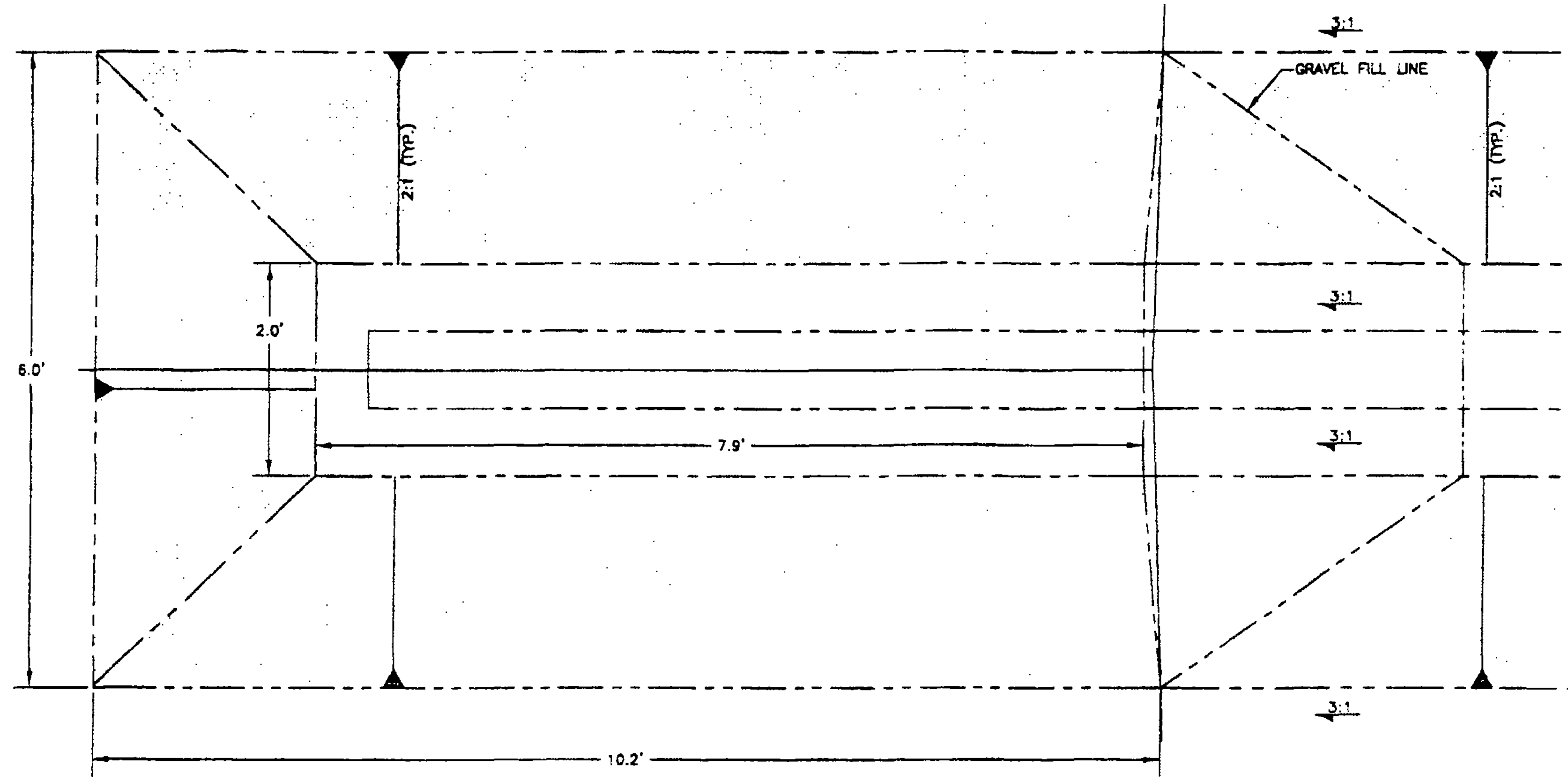
SHEET 14

113-30-100



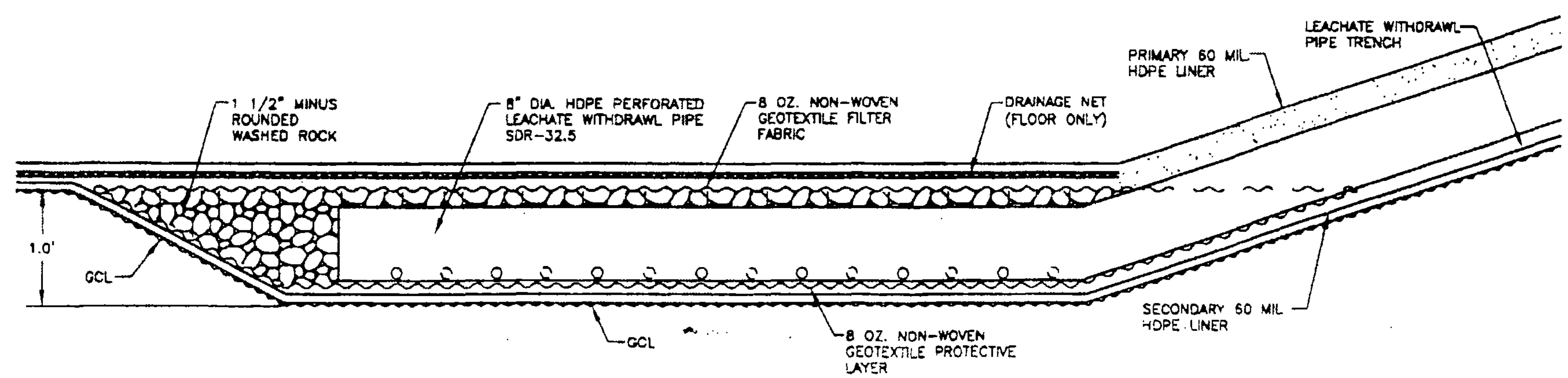
LEACHATE POND PLAN A / 4

N.T.S.



LEAK DETECTION SUMP A / —

N.T.S.



LEAK DETECTION SUMP SECTION 1 / —

N.T.S.

FILE: ...\PERMIT DWGS\LEACHATE POND.DWG (JDB) ...20.2004 13:23:17

HANSEN ALLEN & LUCE INC ENGINEERS

PROJECT ENGINEER

DESIGNED MPW, KCS	3				
DRAFTED	2				
CHECKED KCS	1				
DATE DECEMBER 2004	NO.	DATE	REVISIONS	BY	APVD.

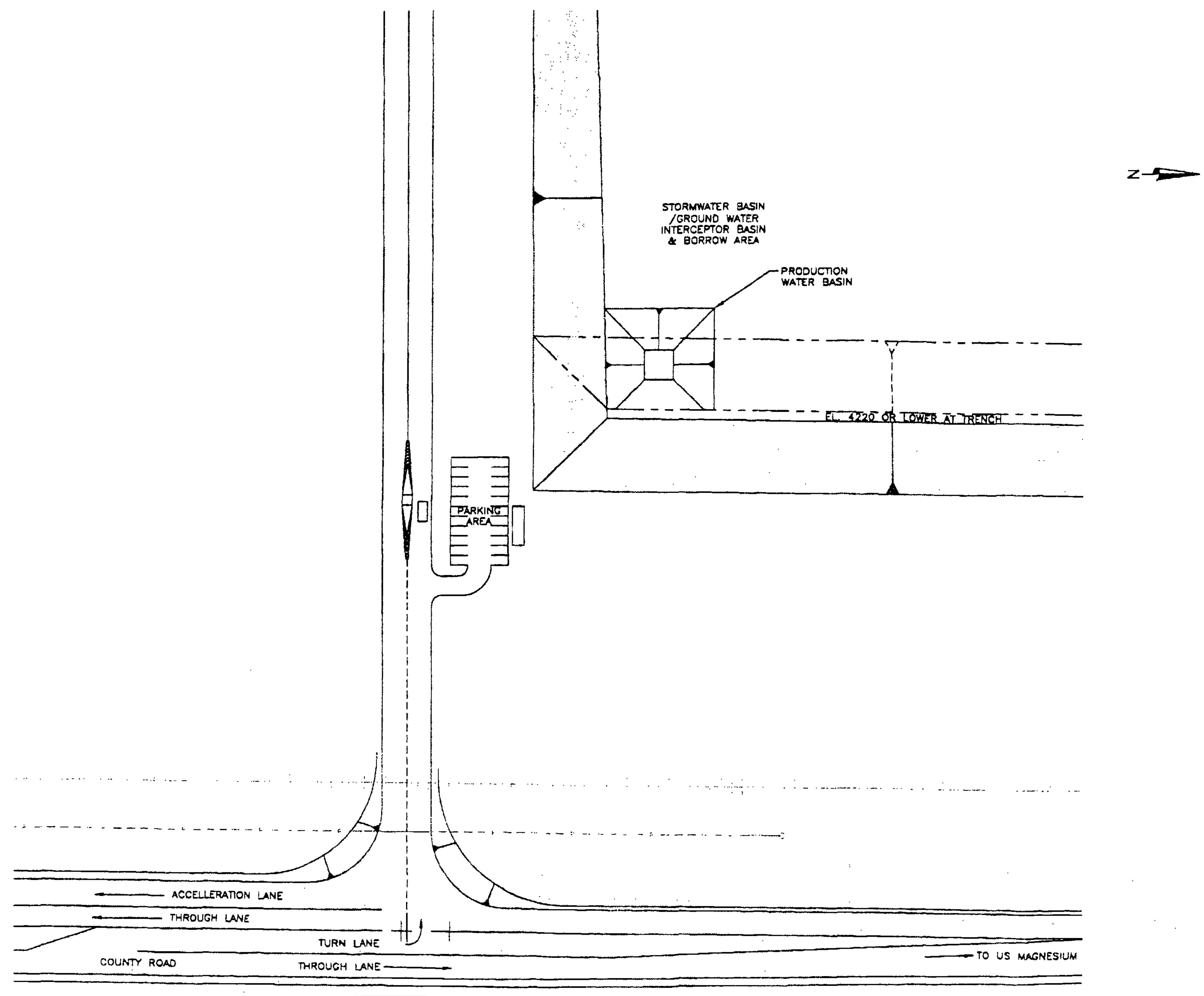
SCALE

WASATCH REGIONAL

WASATCH REGIONAL LANDFILL FACILITY

LEACHATE EVAPORATION POND DETAILS

SHEET 15



HANSEN ALLEN & LUCE inc	DESIGNED MPW, KCS / DRAFTED CAH / CHECKED KCS	SCALE NOT TO SCALE	WASATCH REGIONAL	WASATCH REGIONAL LANDFILL FACILITY / FACILITY ACCESS ROAD	SHEET 16

APPENDIX 6.2
AGEC 2004 Geotechnical Report

AGEC

Applied Geotechnical Engineering Consultants, P.C.

GEOTECHNICAL INVESTIGATION
PERMIT MODIFICATION

WASATCH REGIONAL SOLID WASTE LANDFILL
SECTION 33 AND WEST HALF SECTION 34
TOWNSHIP 2 NORTH, RANGE 8 WEST
AND SECTION 4, WEST HALF SECTION 3
TOWNSHIP 1 NORTH, RANGE 8 WEST
TOOELE COUNTY, UTAH

PREPARED FOR:

WASATCH REGIONAL LANDFILL
C/O HANSEN, ALLEN AND LUCE INCORPORATED
6771 SOUTH 900 EAST
MIDVALE, UTAH 84047

ATTENTION: KENT STAHELI

PROJECT NO. 1040644

DECEMBER 17, 2004
REVISED JUNE 15, 2005

600 West Sandy Parkway • Sandy, Utah 84070 • (801) 566-6399 • FAX (801) 566-6493

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EXECUTIVE SUMMARY

1. The natural soil and bedrock at the site are suitable for support of the proposed landfill disposal facility.

2. Exterior slopes of 3:1 and interior cut and fill slopes of 2:1 (horizontal to vertical) may be used for the base of the landfill facility.

   The final exterior slope of 4:1 will provide satisfactory stability of the waste pile.

4. The natural soil is suitable to use in construction of the proposed embankment.

5. As proposed, a geosynthetic clay liner will also provide appropriate stability along with the other synthetic materials for the interior landfill bottom and also the closure cap.

6. Bentonite from a GCL was tested with water leached from soil samples at the site indicate a permeability of 1.5×10^{-9} cm/sec.

7. Design details and construction precautions are contained in the text of the report.

SCOPE

This report presents the results of a geotechnical investigation for the permit application of the proposed Wasatch Regional Solid Waste Landfill. The facility is to be located west of Rowley Road, approximately 6 miles north of Interstate 80 within the western half of Section 3 and Section 4 of Township 1 North, of Range 8 West along with the western half of Section 34 and Section 33 of Township 2 North, Range 8 West, Salt Lake Base and Meridian in Tooele County, Utah. The revision to the report was requested to include a geosynthetic clay liner (GCL) between the flexible membrane liner (FML) and the cover material on the closure cap.

The subsurface information, geology, seismic conditions along with characteristics of the on-site materials contained within a geotechnical report for the Wasatch Regional Solid Waste Landfill in Tooele County, Utah prepared by Kleinfelder and reported on May 18, 2004 under their File No. 35467.003 has been relied upon in this study.

This report provides the information requested in our proposal dated July 15, 2004 addressed to Allied Waste in care of Hansen, Allen and Luce Incorporated. The items requested for this study include the following:

- Characterize the subsoils.
- Determine the suitability of the subsoils for support of the proposed landfill.
- Provide recommendations for foundation preparation for the landfill.
- Provide recommendations for embankments that would be constructed in conjunction with the landfill.
- Stability issues using geosynthetics as liner and drainage materials.
- Compatibility of the GCL with the on-site soil and water.
- Seismic characteristics.
- Stability analysis of the closed facility.
- Stability analysis during waste placement.
- Suitability of the on-site soil for use as fill.

- Recommendations for imported fill.
- Fill material compaction criteria.

PROPOSED CONSTRUCTION

We understand that the proposed landfill will be developed by placing an embankment on the east portion of the facility close to the existing elevation of 4246 to 4240 feet. At that point, an embankment would be constructed with a slope of approximately 3:1 (horizontal to vertical) extending up to an embankment crest elevation of 4265. A 25 foot horizontal bench would then be provided with the interior portion of the embankment sloping down into the landfill area at a 2:1 (horizontal to vertical) slope to an elevation of approximately 4244 feet. The floor of the landfill would then extend west at a slope of 1.7 and 1.2 percent. At the end of the floor, the ground surface would then slope up at a 2:1 (horizontal to vertical) slope to the west edge of the landfill. This 2:1 slope will be cut and when needed will receive soil as fill to protect the overlying geosynthetics.

The interior surface of the landfill will be prepared to receive waste by having the following materials placed on the floor, from top down.

Two feet of protective soil cover
Non-woven geotextile
Drainage net
Flexible membrane liner (HDPE)
Geosynthetic clay liner (GCL)
Prepared Subgrade

On the 2:1 interior side slopes, the profile would consist of from top down:

Two feet of protective soil cover (as far up the slope to limit stress on the liner materials)

Flexible membrane liner (HDPE textured)

Geosynthetic Clay Liner (GCL)

Prepared Subgrade

The final configuration of the landfill will extend approximately 100 feet vertical feet from the west inside edge of the embankment up at a 4:1 slope. Included with the slope will be two horizontal benches approximately 25 feet wide. At the top of the 4:1 slope, a small berm will be placed in order to prevent drainage from extending down the slope. The top of the landfill will slope up towards the west at an approximate 5 percent slope. The west edge of the cap will slope down at a 4:1 slope to natural soil.

The profile of the materials on the closure cap will consist of the following (from top down):

Two foot cover material including soil and an erosion protective layer

Textured Flexible Membrane Liner (HDPE)

Geosynthetic Clay Liner (GCL)

Protective soil (approximately 6 inches)

Waste

The 4:1 side slopes will have the following profile (from top down):

Two foot cover material including soil and an erosion protective layer

Textured Flexible Membrane Liner (HDPE)

Geosynthetic Clay Liner (GCL)

Protective soil (approximately 6 inches)

Waste

We anticipate that waste placement will begin at the eastern end (the lowest elevation) and proceed in horizontal lifts until the final profile is achieved.

Approximately 300 feet east of the toe embankment will be the beginning of a borrow area for construction and daily cover soil. It is anticipated that the natural soils will be excavated down to a depth of approximately 20 feet with a perimeter slope of approximately 3:1 and flatter. This area of excavation will extend to within approximately 300 feet of the railroad tracks that parallel Rowley Road.

SITE CONDITIONS

The site is currently vacant of permanent structures with a few dirt roads on the property. The ground surface within the area of the proposed facility currently slopes down towards the east at a slope of approximately 5 percent. Near the toe of the proposed facility, the ground surface is fairly flat.

The site is basically at the foothill of the Lakeside Mountains. Further to the east, the ground surface slopes down to the Great Salt Lake. The lake at its current location is approximately 5 to 6 miles to the east/northeast.

FIELD INVESTIGATION

The subsurface conditions for this phase of the study was conducted by drilling five borings at the locations indicated on Figure 1. Three of the borings were advanced to ground water and monitoring wells constructed. The drilling extended down to a maximum depth of 173 feet. Drilling was initially started using 8-inch, hollow-stem auger powered by an all-terrain (CME 750) drill rig. For the deeper exploration and in more difficult drilling conditions, rotary methods using a 3½ inch diameter tricone bit was used with air as the circulation fluid.

Samples were obtained, with a California spoon sampler with an automatic hammer advancing the samplers. Disturbed bulk samples were also obtained from the cuttings.

The holes constructed to be monitoring wells were completed by estimating the water level and then placing a 15 to 20 foot section of screen with openings of 0.010 inches. A 5 foot section of PVC pipe was placed below the screened portion and solid pipe extended above the screen portion up to the ground surface. Sand was placed within the annular space within the screened section (and 1 to 8 feet above the screened portion) with bentonite chips being used to backfill from the sand portion up to near the ground surface. Concrete was placed in the upper 1¼ feet. The soil borings were backfilled with cuttings.

The California sampler (2 inch diameter) was advanced by driving with blows from a 140 pound automatic hammer falling 30 inches. This test is similar to the standard penetration test as described by ASTM Method D-1587, except the sampler used is a 2 inch diameter sampler as opposed to a 1⅜ inch inside diameter sampler.

Based on studies conducted by Goodman and Carol (Goodman and Carol, Theory and Practice of Foundation Engineering, the McMillam Company, New York, 1968, p 54), the actual measured penetration resistant values obtained using the California sampler should be multiplied by 0.82 to equate them with the penetration resistant values using the standard penetration sampler. Penetration resistant values, when properly evaluated, provide an indication of relative density or consistency of the soils encountered.

Measurements were made in the borings to determine the presence of free water. Water measurements obtained after completion of exploratory borings are shown on the logs of exploratory borings.

LABORATORY TESTING

Laboratory testing was conducted on selected samples of the natural soils in order to determine their engineering characteristics. Laboratory testing conducted during the study includes: natural moisture content, dry density, Atterberg Limits, grain-size distribution, strength, moisture/density relationship and consolidation. The test results are shown on Figures 6 through 18. A summary of the laboratory test results is shown on Table I.

A discussion of laboratory testing procedures is presented below. The testing procedures are primarily those of American Society for Testing and Materials (ASTM).

Index Properties - The unified soil classification system (ASTM D-2487) was used to classify the soil. This system is based on index property tests including the determination of natural water content (ASTM D-2216), liquid and plastic limits (ASTM D-4318) and grain-size distribution (ASTM D-422). Results of the moisture content, dry density, Atterberg Limits and percentage of soil passing the No. 200 sieve are presented on Table I.

Consolidation - Consolidation tests were performed during this investigation. Consolidation test samples were prepared and placed in a consolidometer ring between porous disks. An initial seating load of 500 pounds per square foot was placed on the sample. The sample was then loaded to 1,000 pounds per square foot. The percent change in sample heights was measured with a dial gauge as the sample was wetted and loaded incrementally until a straight line relationship between load and strain was obtained. In two cases, the loads were reduced to measure the rebound portion of the consolidation curve. The consolidation test procedure described is similar to ASTM Method D-2435. Results of consolidation tests are plotted as a curve of the final strain at each increment of pressure against the log of accumulated pressure. These tests are shown on Figures 12 through 14.

Triaxial Shear - A triaxial shear test was performed in general accordance with ASTM D-4767. The sample was prepared by trimming the ends perpendicular to the sample axis and placing it in a latex membrane. The prepared sample was placed in the triaxial cell and was saturated using back pressure saturation. Testing continued by placing a consolidation load of 7 psi and then shearing the sample to near failure. The sample was then reconsolidated at 14 psi and then again sheared to near failure. The sample was then consolidated at 28 psi and this time sheared to failure. Sample strains, loads and pore pressures were monitored throughout each stage of the test. The test results are shown on Figure 8.

Direct Shear - Direct shear tests were conducted in general accordance with ASTM D-3080 on undisturbed samples of the soil. Each sample was consolidated at loads of 1, 2 and 4 kips per square foot. After each of the consolidation pressures, the sample was sheared with the peak strength being obtained. The test results are presented on Figures 9, 10 and 11.

Leached Water - Four samples of on-site soil were returned to the laboratory and were used to obtain water leached from the soil. This process was conducted in accordance with ASTM D-6151. The leached water was then used to measure the Atterberg Limits of two possible sources of bentonite for the geosynthetic clay liner, and also was used as the permeant in a permeability test of a GCL bentonite.

Permeability - Bentonite taken from a sample of the potential geosynthetic clay liner was tested for permeability using one of the leachates obtained from the on-site soil. The test was conducted following ASTM D-5084-90 procedure.

LABORATORY TEST RESULTS

Listed below is a summary of the index properties for the soils encountered by AGEC and also Kleinfelder.

Soil Index Properties

Soil Type	Gravel (percent)	Sand (percent)	Clay Silt (percent)	Liquid Limit (percent)	Plasticity Index (percent)
Lean Clay	0 - 1 (0)	10 - 33 (25)	51 - 97 (28)	26 - 102 (44)	10 - 53 (18)
Silty Clay	0 - 1 (0)	21 - 36 (28)	51 - 87 (71)	21 - 49 (30)	0 - 19 (9)
Silty Sand	0 - 20 (7)	49 - 92 (73)	5 - 66 (31)	20 - 29 (22)	0 - 9 (2)
Sandy Gravel	11 - 70 (47)	20 - 35 (30)	8 - 56 (29)	40	26

Note: The values above are the ranges of samples tested within the general deposit. The numbers in ( ) are average values.

The engineering characteristics of the natural soils were also determined by the consolidation and strength tests. Listed below is a summary of the strength and compressibility characteristics.

Strength - Direct Shear Test

Location	Tested by	Friction (degrees)	Cohesion (psf)	Remarks
B - 2 @ 2'	Kleinfelder	35	550	Remolded to 95%
B- b @15'	Kleinfelder	29	75	Remolded to in-situ conditions
B - 10 @ 10'	Kleinfelder	31	0	Remolded to in-situ conditions
B - 2 @ 34'	AGEC	35	40	Undisturbed
B - 3 @ 14'	AGEC	33	0	Undisturbed
B - 4 @ 14'	AGEC	30	100	Undisturbed

Strength - Triaxial Shear Test

Location	Tested by	Friction (degrees)	Cohesion (psf)	Remarks
B - 4 @ 24'	AGEC	32	80	Effective Stress Parameters
		26	160	Total Stress Parameters

Strength - Unconfined Compression Test

Location	Tested by	Compressive Strength (psf)
B - 11 @ 10'	Kleinfelder	3580

Consolidation Testing

Boring	Depth	Tested by	Cr′	Cc′	mpp	Description
B - 2	5'	Kleinfelder	0.018	0.177	900	Lean Clay w/Sand
B - 3	7½'	Kleinfelder	0.014	0.005	7000	Sandy Lean Clay
B - 4	15'	Kleinfelder	0.022	0.064	2000	Sandy Lean Clay
B - 5	7½'	Kleinfelder	0.007	0.108	5000	Sandy Silty Clay
B - 9	8'	Kleinfelder	0.015	0.081	4000	Clayey Sand
B - 9	30'	Kleinfelder	0.022	0.118	4200	Elastic Silt
B - 11	10'	Kleinfelder	0.010	0.165	2200	Silt w/Sand
B - 1	68'	AGEC	0.01	0.092	—	Sandy Lean Clay
B - 3	29'	AGEC	0.008	0.101	2000	Lean Clay
B - 4	19'	AGEC	—	0.070	—	Sandy Silt

In order to determine the potential impact of dissolvable salts on the performance of bentonite from the GCL, leached water from four soil samples at the site and were used to conduct Atterberg Limit tests and a permeability test. The test results from the soil samples and the effect of the leached water on the Atterberg Limits are listed below:

Location of Leached Soil Sample

Sample Designation	Sample Location
A	Northwest Area of Property
B	Midpoint on South Side of Property
C	Near Kleinfelder B-3
D	Near Kleinfelder B-5

The index properties of the soils tested of the samples obtained are indicated below:

Leached Soil Index Properties

		Gradation			Atterberg Limits	
Sample	Moisture Content (%)	Gravel +4 (%)	Sand -4 & +200 (%)	Silt/Clay 200 (%)	Liquid Limit (%)	Plasticity Index (%)
A	6	1	60	39	22	6
B	6	0	9	91	18	1
C	5	0	18	82	22	6
C	2	0	61	39	17	2

Listed below is a summary of the test results using this water with the two different bentonites.

Atterberg Limits with Various Water Sources

Water Source	Atterberg Limit Test Results			
	Cetco bentonite		GSE bentonite	
	LL	PI	LL	PI
Distilled Water	492	470	532	503
Site Piezometer Water	353	329	284	255
Sample A Leached Water	306	281	264	240
Sample B Leached Water	461	437	524	492
Sample C Leached Water	411	387	439	409
Sample D Leached Water	352	328	289	256

The permeability of the GSE bentonite using Sample A leached water was measured to be 1.5 x 10^{-9} cm/sec.

SUBSURFACE CONDITIONS

Subsurface conditions at the site were characterized by the exploratory borings drilled by AGEC and the subsurface information reported by Kleinfelder. The subsurface profile consists of clay, silt and fine sand on the lower elevation portions of the site with more granular materials being encountered on the higher elevation portions of the site. Bedrock was encountered in one of the borings at a depth of 143 feet (Boring B-1). The bedrock was found to be limestone.

A general description of each of the soil types encountered in the borings is indicated below:

Lean Clay - The lean clay was found to be interlayered with sandy silt and occasionally some silty sand. The clay was found to be stiff to very stiff, slightly moist to moist and brownish gray in color.

Silty Clay - The silty clay was found to be sandy and medium to soft and wet. The color of was found to be gray.

Silty Sand - The silty sand was found to contain occasional lean clay layers. The silty sand was found to be loose to dense. The moisture condition varied from moist to wet and the color was gray to grayish brown.

Sandy Gravel - The sandy gravel was found to be silty and clayey. Occasional cobble and boulders were also encountered. The density of this deposit was found to be medium to very dense. The moisture condition was generally moist to wet and the color was brownish gray.

Bedrock - The bedrock encountered consisted of limestone. It was also found to be gray.

FREE WATER

Water was encountered in the deeper borings at an approximate elevation of 4220 to 4235.

EMBANKMENT

A. Section

A typical embankment section for the proposed landfill cell is shown on Figure 19. The proposed section as described earlier, consists of an exterior slope of 3:1 and an interior slope of 2:1 (horizontal to vertical). The embankment will have a top crest width of 25 feet at a top elevation of 4265. It is our understanding that the embankment will be constructed as a homogeneous compacted earth fill section with synthetic materials on the interior portion of the slope. The overall exterior height will be from 15 to 19 feet. With the top elevation of 4265 and the interior toe elevation of 4244, the interior 2:1 slope will be 21 feet high.

B. Stability

Stability of the proposed embankment and landfill was analyzed under several loading conditions. Factors of safety for the embankment were determined with respect to mass rotational and sliding wedge failures. Static and dynamic (pseudo) static analysis of the embankment was conducted using the configuration discussed above.

1. Soil Profile

The soil profile used in the stability analysis of the embankment and landfill was defined from the information obtained from the exploratory borings and laboratory test results. The soil profile assumed is the weaker of the materials encountered and consists of clay, silty clay and silty sand. A graphic presentation of the soil profile used in the analysis is shown on Figure 19.

2. Moisture Conditions

No free water was included in the evaluation of the embankment slope other than the ground water elevation of 4235 feet was on the east and up to 4260 on the west.

The potential of water entering the embankment would be limited to surface infiltration from the exterior portion of the embankment. The interior portion of the embankment will be covered with impervious synthetic liners. With this condition, the embankment and foundation soils were evaluated assuming drained conditions. Due to the significant amount of sand, the interlayered conditions of the fine-grained soil and the extended period of time for placement of fill and waste, the natural soils were evaluated under drained conditions.

3. Seismic Considerations

The seismic conditions, as reported by the USGS (2003) were used to evaluate the stability of the embankment under seismic conditions. The USGS indicates an acceleration that has a 2 percent probability of exceedance in 50 years (10 percent in 250 years) results in an acceleration of approximately 0.210g.

This acceleration was adjusted for the stability analysis as recommended in the DMG Special Publication 117 "Guidelines for Analyzing and Mitigating Landslide Hazards in California". Using this document, an acceleration of 0.092g was used for the stability calculations assuming a threshold 15cm displacement.

4. Strength Parameters

The strength parameters used for the stability analysis were determined from the field and laboratory test results conducted in this study and also by Kleinfelder. The testing consisted of penetration resistances, unconfined compressive strength tests, triaxial shear tests and direct shear tests conducted on undisturbed and remolded soil samples. Based on these results, previous testing by others and our judgment, strength parameters for each material were selected.

A table summarizing the waste and soil materials and their strengths is indicated below:

Strength Parameters - 1

Material	Unit Weight (pcf)	Friction (degrees)	Cohesion (pcf)
Waste	120	25	100
Embankment	120	32	300
Clay, Silt, Silty Sand (Fine)	105	31	40
Gravel (Coarse)	130	37	0

A table summarizing the synthetic/soil materials and their internal and interface strength parameters are listed below:

Strength Parameters - 2

	Internal		Interface	
	Friction (degrees)	Cohesion (psf)	Friction (degrees)	Cohesion (psf)
A - Floor				
Waste	25	100		
			25	100
Soil Cover	25	100		
			21	80
Non-woven Geotextile	—	—		
			8	0
Drainage Net	—	—		
			9.4	0
HDPE	—	—		
			8	0
GCL	18	50		
			26.8	30
Soil	31	40		
B - Side Slope (2:1 Slope)				
Waste	25	100		
			25	100
Soil Cover	25	100		

	Internal		Interface	
	Friction (degrees)	Cohesion (psf)	Friction (degrees)	Cohesion (psf)
			23.9	95
HDPE (Textured)	—	—		
			21	250
GCL	18	50		
			26	30
Soil	31	40		
C - Cap (4:1 Slope)				
Soil	25	100		
			23.9	95
HDPE (textured)	—	—		
			21	250
GCL	18	50		
			21	80
Soil	25	100		
			25	100
Waste	25	100		
D - Cap (top)				
Soil	25	100		
			21.4	84
HDPE (textured)	—	—		
			21	260
GCL	18	50		
			21.4	8.4
Soil	25	100		
			25	100
Waste	25	100		

The interface strength parameters where specific test values were not available were selected by taking the weaker strength of 1) the adjacent material, 2) approximately 84 percent of the weaker materials if a smooth synthetic material is included or 3) 95 percent of the weaker materials if a textured synthetic is included.

5. End of Construction - Long Term Conditions

Typically, in a clay soil environment, construction of an embankment may induce excessive pore pressure in the foundation soil. With the excessive pore pressure, the friction resistance of the clay soils against sliding may not increase with the addition of load. To model this condition where the excess pore pressures reflect the addition of embankment material or waste, an end of construction analysis is conducted of the embankments.

Under long term conditions, excess pore pressures which may have developed during construction are assumed to have dissipated, thus mobilizing the friction resistance available in the foundation soils. We have assumed this condition under the long-term condition and during placement of waste within the landfill. We anticipate that the landfill is large enough and that the placement of waste would not result in a significant increase of pore pressure.

With the clay, silty sand to sandy silt material used for embankment construction, the strength parameters for both end of construction and long term conditions for the embankment were assumed to be in a drained condition.

6. Bearing Capacity

Soil bearing capacity with respect to the proposed landfill was evaluated. The stability calculations summarized in the next section also models a bearing capacity type failure. A bearing capacity type failure is defined as the lack of strength within the foundation soils versus support of the proposed construction. Typically, the bearing capacity of an embankment is evaluated by conducting stability analysis.

Classical bearing capacity calculations have been conducted to determine the bearing capacity of the natural soils with respect to the proposed embankment construction and under the loading conditions resulting from completed disposal cell. A safety factor greater than 3 with regards to classical bearing capacity is calculated for the embankment alone at the level of the softest natural soils. In these calculations, it was assumed that the soft clay material extends to great depth.

Based on the calculations for bearing capacity and the information obtained during the slope stability evaluation, we believe that the natural soil will support the proposed construction and will result in suitable factors of safety against bearing capacity type failures.

7. <u>Stability Calculations</u>

The stability of the proposed embankment and landfill was analyzed under several loading conditions. Factors of safety for the embankment and the completed landfill were determined against mass rotational and sliding wedge failures. Static and dynamic (pseudo static) analyses of the embankment and disposal cell were conducted using the configuration as described. Strength parameters used in the stability analysis are listed on Figure 19.

Rotation failure analysis were conducted on the proposed embankment and on the filled landfill cell aided by a computer. The stability program which models this method was developed by Ronald A. Seagull, graduate instructor in research, Purdue University as a joint highway research project in cooperation with the Indiana State Highway Commission.

Stability calculations indicate that the defined embankment and cut/fill section has a static safety factor under long term conditions of approximately 1.5. For the seismic long term conditions, the stability for the embankment alone is calculated to be 1.3.

Calculations indicate that if pore pressures within the foundations soils were increase to a level equivalent to the amount of fill placed for the embankment (end of construction) a static safety factor would be 2.1.

Stability calculations for the final configuration of the landfill indicate a static safety factor of 2.3 with a minimum calculated seismic safety factor of 1.6.

A summary of the safety factors obtained are included on Figure 19 with the critical failure planes indicated.

Recommended minimum factors of safety are dependent on the uncertainty of soils strength parameters and the cost of consequences of slope failure. The Environmental Protection Agency recommends use of minimum static factor of 1.5 for a slope where the cost of repair is comparable to the cost of construction and if there is no danger to human life or other valuable property if the slope fails with large uncertainty in soil strength parameters. The corresponding minimum factor of safety under seismic conditions is 1.3. (Guide to Technical Resources for the Design of Land Disposal Facilities, EPA/625-6-88/018, December 1988, Risk Reduction Engineering Laboratory and Center for Environmental Research Information, Office of Research and Development, USCPA, Cincinnati, Ohio 45628.)

Based on the subsoils encountered, laboratory test results, stability analysis and given loading conditions, the embankment and proposed landfill cell meet the minimum safety factors.

8. Synthetic Slope Stability

Each of the synthetic liner areas contains dissimilar materials or is constructed of dissimilar materials which have significantly different friction factors or resistance to sliding. The weakest interface was evaluated on an infinite slope type of evaluation under both static and pseudo static conditions. Listed below is a table summarizing the location of the synthetic liner system, the weakest friction value, the slope upon which the material is placed and the static and pseudo static factors of safety.

Location	Weakest Interface	Friction (degrees)	Cohesion (psf)	Slope (H:V)	Safety Factor	
					Static	Seismic
Interior Slope	GCL/Soil	26	30	2:1	1.2	1.0
Floor	HDPE/GCL	8	0	1.7%	8	1.3
Cap (Slope)	GCL	18	50	4:1	11	4
Cap (Top)	GCL	18	50	5%	2.2	1.6

Note: The interior slope was evaluated with 20 feet of protective soil cover sloped at 2.5:1.

These results indicate that the synthetic materials, as currently designed, meet the minimum criteria for factors of safety except for the interior 2:1 slopes. The integrity and desired factor of safety may be achieved on the 2:1 slopes by placing the soil protective cover in 10-foot vertical stages or by verifying that the interface strength between the GCL and underlying soil on the slope is greater than we have assumed. The literature indicates that a higher strength will most likely apply. We recommend that the strength of the proposed synthetic materials and the underlying soils be verified prior to construction.

C. Settlement

Based on the subsurface information, along with the anticipated weights of the waste material and configuration of the landfill, the amount of settlement that will likely be experienced by the facility was estimated. Due to the variation in the waste height, along with the anticipated variation and, therefore, compressibility of the foundation soils, we estimate that the total settlement on the upper toe (west end) of the floor of the landfill to be approximately 5 inches with the settlement at the toe at the east end of the facility will be approximately 1 to 2 feet. The variation in settlement will depend on the load and also the subsurface soil conditions. We estimate, however, that this will happen fairly gradually and will not be detrimental to the performance of the liner system.

D. *Liquefaction*

The density and type of soil encountered during this and Kleinfelder's study indicate that there may be thin, dis-continuous layers of soil that may be subject to liquefaction during a major seismic event.

The locations where the soil is potentially liquefiable, as delineated by Kleinfelder are in the borrow area, and not under the landfill. The subsurface soil investigated during this study was found to not be susceptible to liquefaction at an acceleration with a 5% probability of exceedance within 50 years.

Based on the proposed construction, the existing soil conditions, the depth of ground water, and the increased stress on the underlying soil due to the placement of the waste, it is our professional opinion that the likelihood of liquefaction is very low and would require an acceleration higher than predicted to have a 2 percent probability of exceedance in 50 years.

GCL COMPATIBILITY

Due to the salty environment of the site, tests were conducted in order to verify that the GCL will perform as intended even under adverse conditions of the site.

A sample of bentonite from two different suppliers were obtained and tested for their Atterberg Limits using distilled water, water obtained from a piezometer at the site, along with a water leached from soil obtained from four different locations at the site.

The testing indicates the greatest impact on plasticity of the bentonite to be with water leached through Sample A. Using the Sample A leached water, a permeability test was conducted on the "GSE" bentonite with a permeability of 1.5×10^{-9} cm/sec.

CONSTRUCTION CONSIDERATIONS

Based on the subsurface investigation, the proposed materials and our experience with this type of construction, the following precautions should be observed during design and construction of the proposed landfill.

A. Foundation Preparation

Foundation preparation consists of removing any disturbed soils in the area of proposed construction. Any vegetation or debris that is within the areas to receive fill should be removed. Positive measures should be taken to remove any material in any compactive areas that do not meet the compaction criteria.

B. Embankment Construction

1. Materials

The embankment may be constructed with a mixture of clay, silt, sand or gravel soils. This indicates that any of the soil encountered at the site would be potentially suitable.

Materials for construction of the embankment are available from the surrounding area.

2. Compaction

All fill within the embankment should be placed and compacted to at least 95 percent of the maximum dry density as determined by ASTM D-698. Moisture content of the fill would be at or above optimum moisture content to facilitate the compaction process.

Fill should be placed in uniform lifts not more than 8 inches thick prior to compaction. Compaction should be accomplished with heavy compaction equipment.

Lifts compacted by hand operated equipment should be no more than 4 inches in loose thickness.

3. Benching

Fill placed on slopes steeper than 5:1 (horizontal to vertical) should be benched into the slope with benches no greater than 2 feet. In areas where the slope is irregular and in rock, the need for benching may be eliminated.

4. <u>Erosion Protection</u>

Exterior portions of the embankment may be protected to reduce erosion or repaired when needed.

5. <u>Construction Quality Control</u>

The materials are to be observed and tested by a representative of the soils engineer to verify that the densities and moisture contents meet the project specifications.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings drilled at the approximate locations indicated on the site plan and the data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface conditions or groundwater level are found to be significantly different from those described above, we should be notified to reevaluate our recommendations.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

REGISTERED PROFESSIONAL ENGINEER
No. 143916
JAMES E.
NORDQUIST
6/13/05
STATE OF UTAH

James E. Nordquist, P.E.

JEN/sc

REFERENCES

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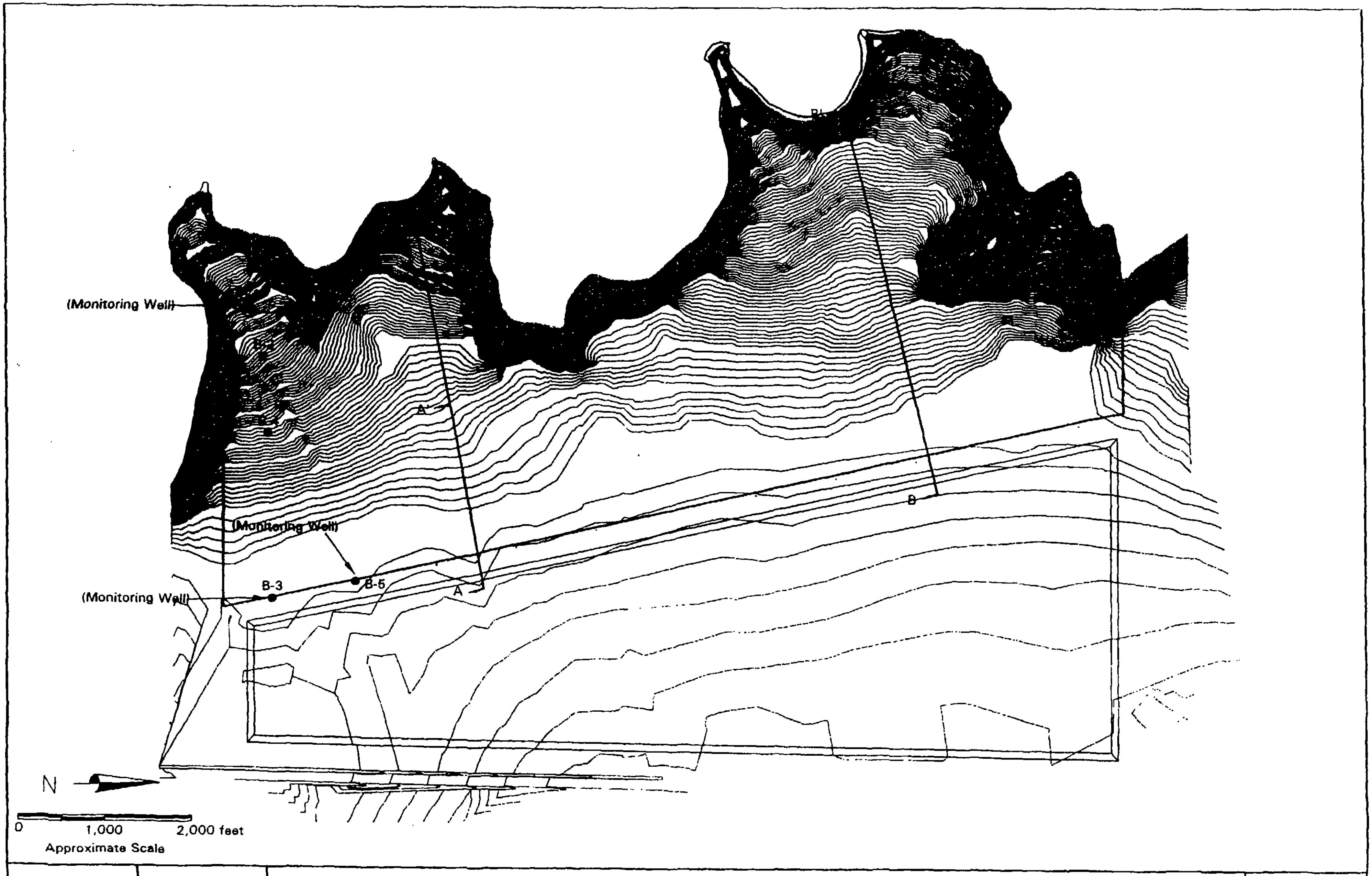
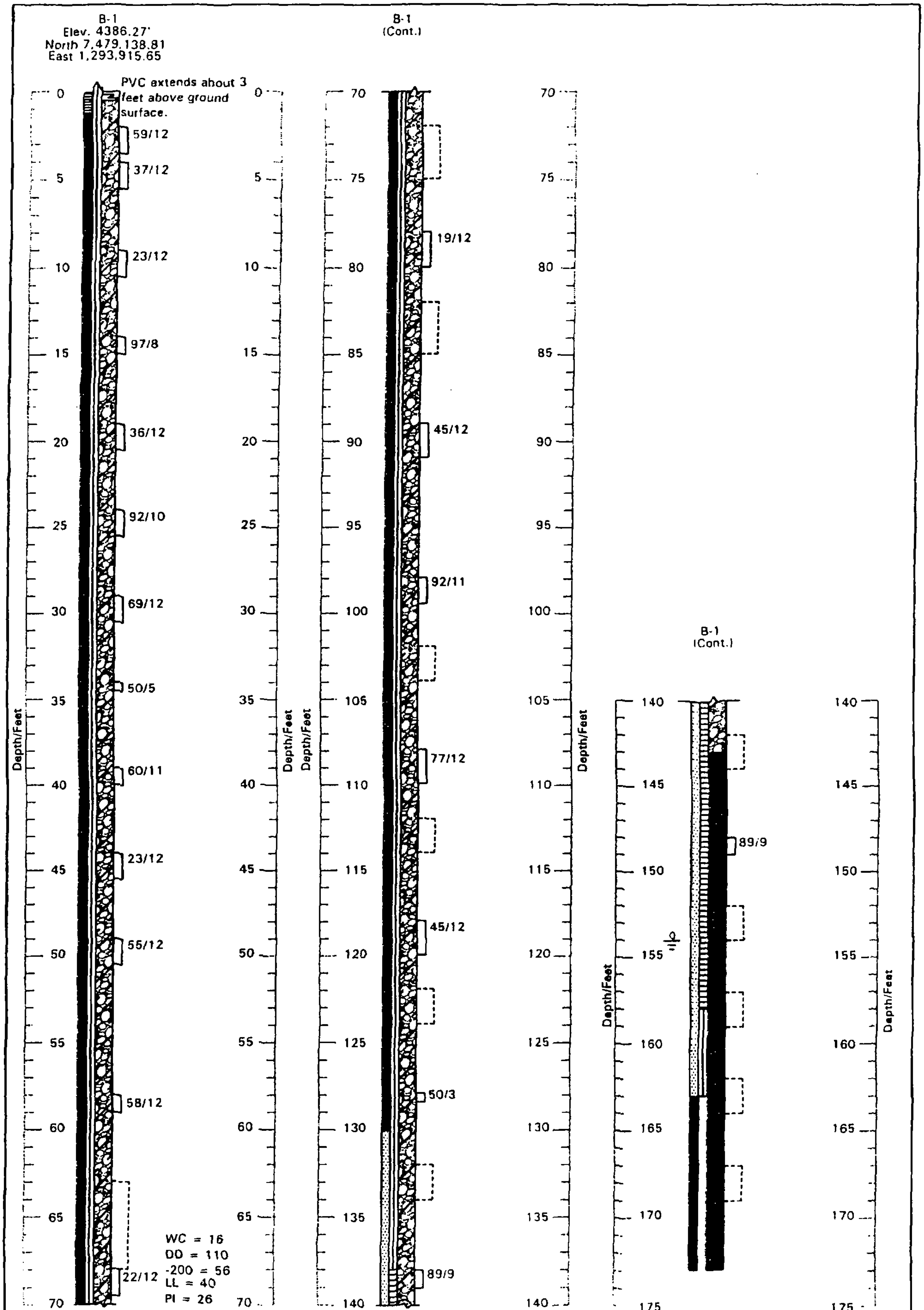


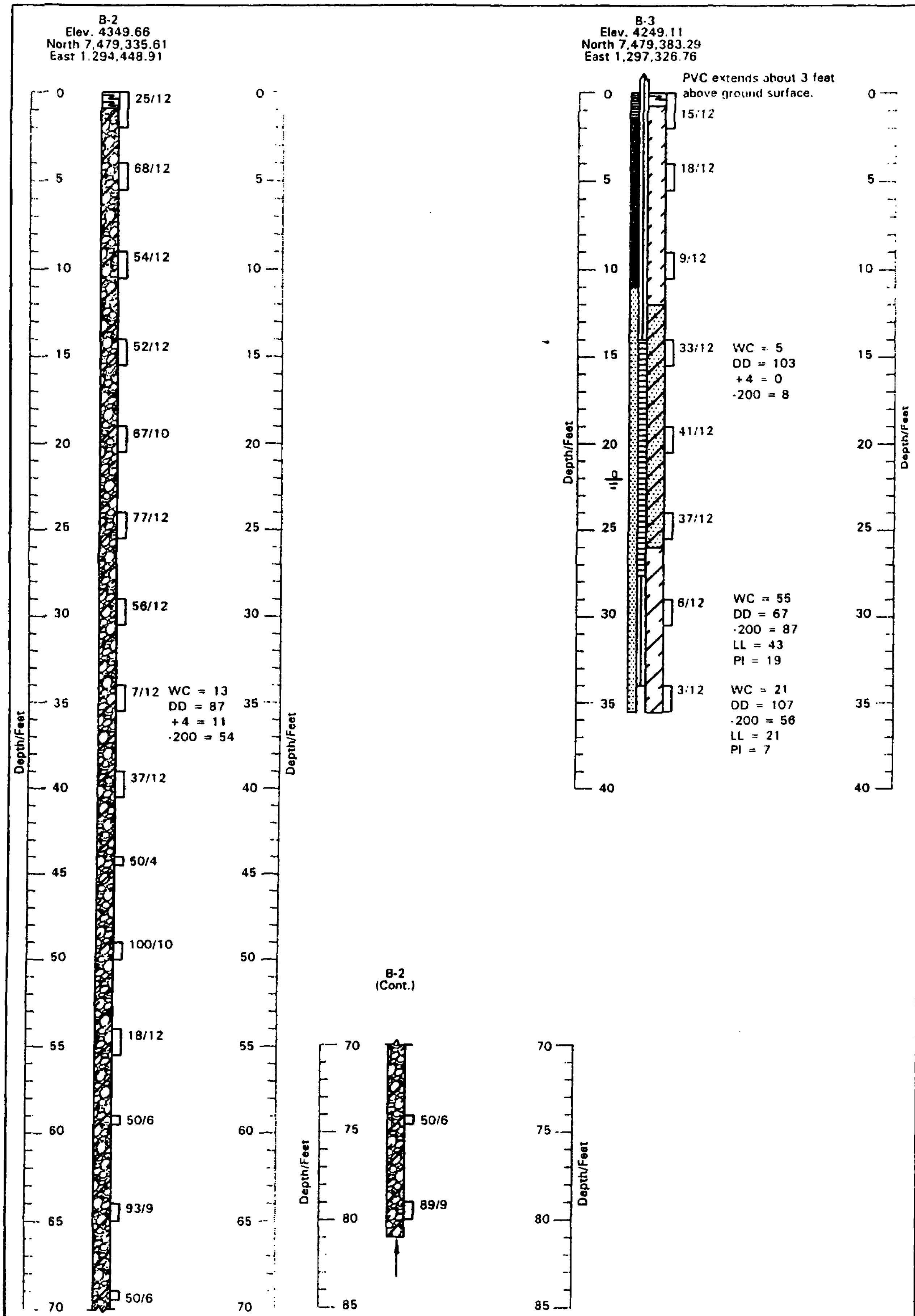
(Monitoring Well)
B'
A'
B
(Monitoring Well)
B-3
B-5
A
(Monitoring Well)
N
0
1,000
2,000 feet
Approximate Scale



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes

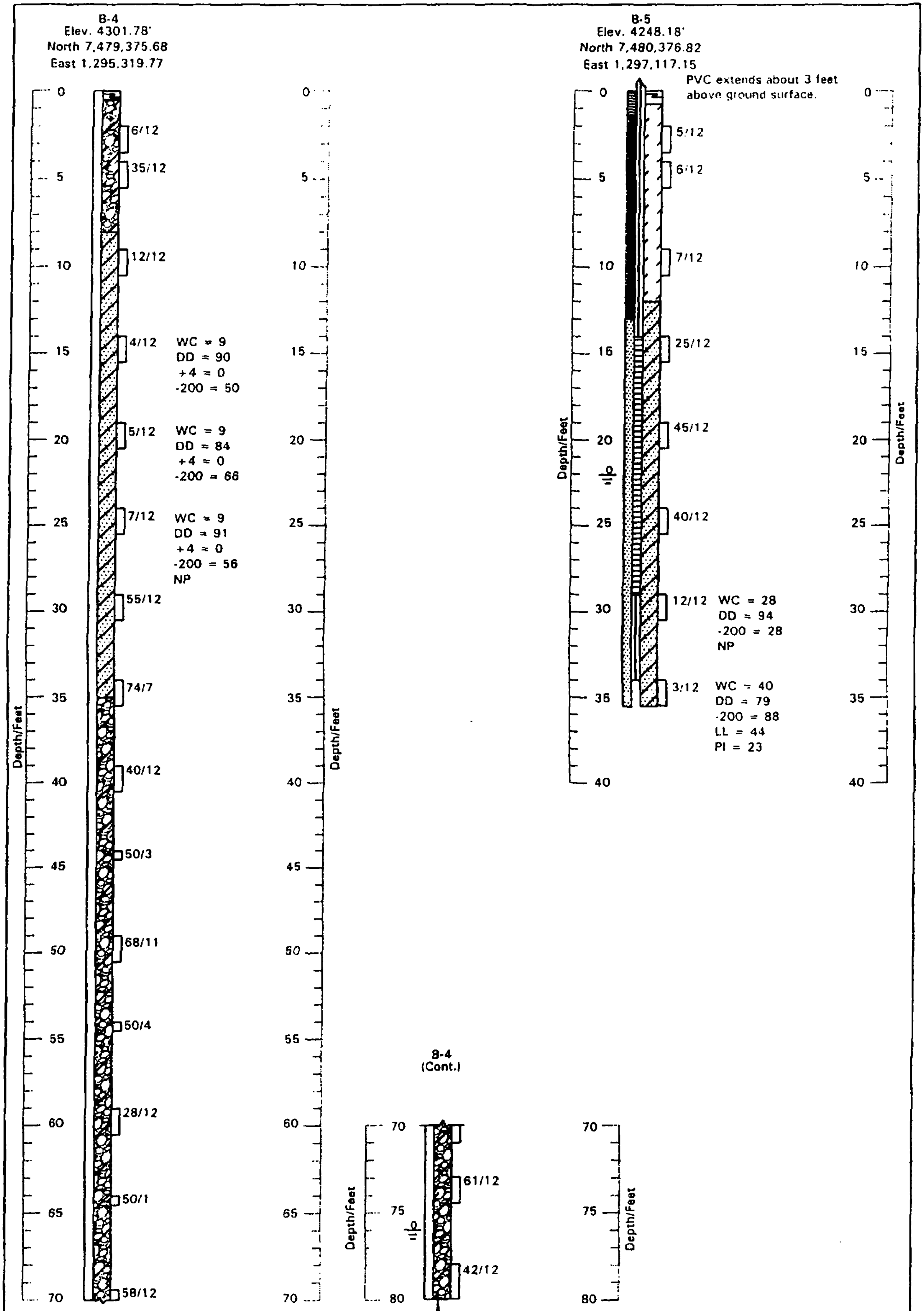
1040644	AGES	Logs of Exploratory Borings	Figure 2



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes

1040644	AGEX	Logs of Exploratory Borings	Figure 3



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes

1040644	AGEC	Logs of Exploratory Borings	Figure 4

LEGEND:

Topsoil;

Lean Clay (CL); interlayered with sandy silt, stiff to very stiff, slightly moist to moist, brownish gray.

Silty Clay (CL-ML); sandy, medium to soft, wet, gray.

Sand (SM); silty, occassional lean clay layers, loose to dense, moist to wet, gray to grayish brown.

Gravel (GM/GC); sandy, silty and clayey, occassional cobble and boulders, medium to very dense, moist, brownish gray.

Gray Limestone

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates disturbed sample taken.

Indicates slotted 1 ½ inch PVC pipe installed in the boring to the depth shown.

0 Indicates the depth to free water and the number of days after drilling the measurement was taken.

Indicates screened portion of monitoring well. Screen slots 0.010 inches.

Indicates solid 2" diameter PVC pipe.

Indicates annular space backfilled with Portland Cement Concrete.

Indicates annular space backfilled with bentonite.

Indicates annular space backfilled with sand.

NOTES:

1. Borings were drilled on October 13, 14, 15, 18, 20, 21, 22, 25, 26, 27, 28 and 29, 2004 with 8-inch diameter hollow-stem auger and 3.5 inch tri-cone bit with air circulation.
2. Locations of borings were provided by civil engineer.
3. Elevations of borings were measured by civil engineer.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.
7. Monitor wells were completed with a 4 inch square steel locking cover set in a 2 foot square concrete slab. The 2-inch diameter PVC pipe protected by the well cover extends to approximately 3 feet above the ground surface.
8. WC = Water Content (%);
   DD = Dry Density (pcf);
   +4 = Percent Retained on No. 4 Sieve;
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   NP = Non Plastic

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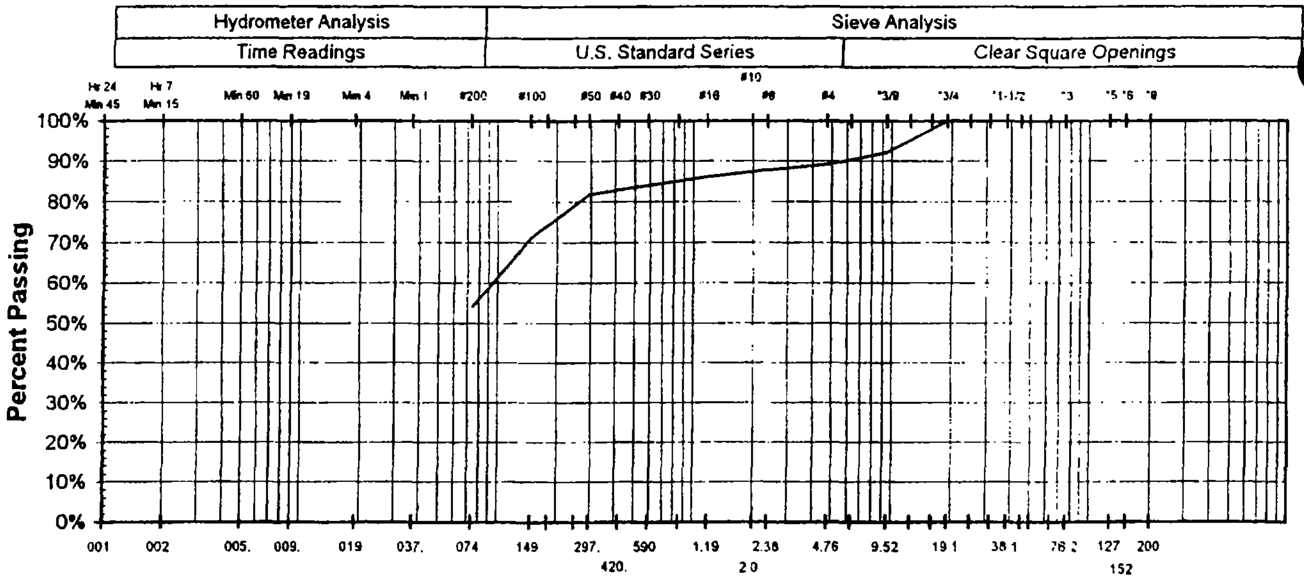
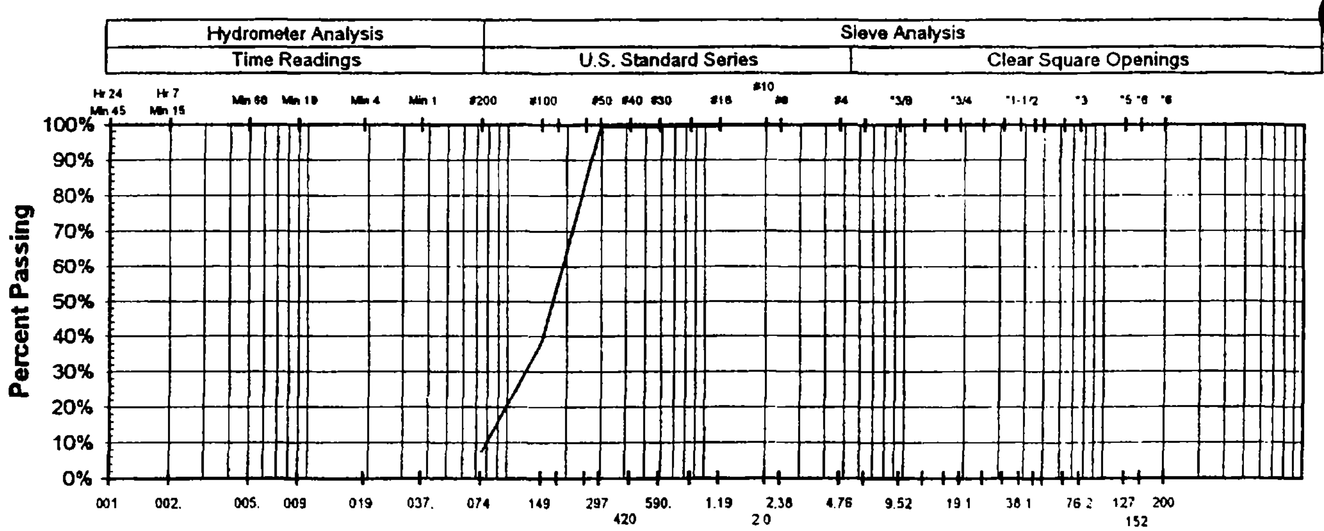


Diameter of Particle in Millimeters

Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel 11%
Sand 35%
Silt and Clay 54%
Sample Description Sandy Silt

Liquid Limit -
Plasticity Index -
Sample Location B-2 @ 34'



Diameter of Particle in Millimeters

Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel 0%
Sand 92%
Silt and Clay 8%
Sample Description Poorly Graded Sand with Silt

Liquid Limit -
Plasticity Index -
Sample Location B-3 @ 14'

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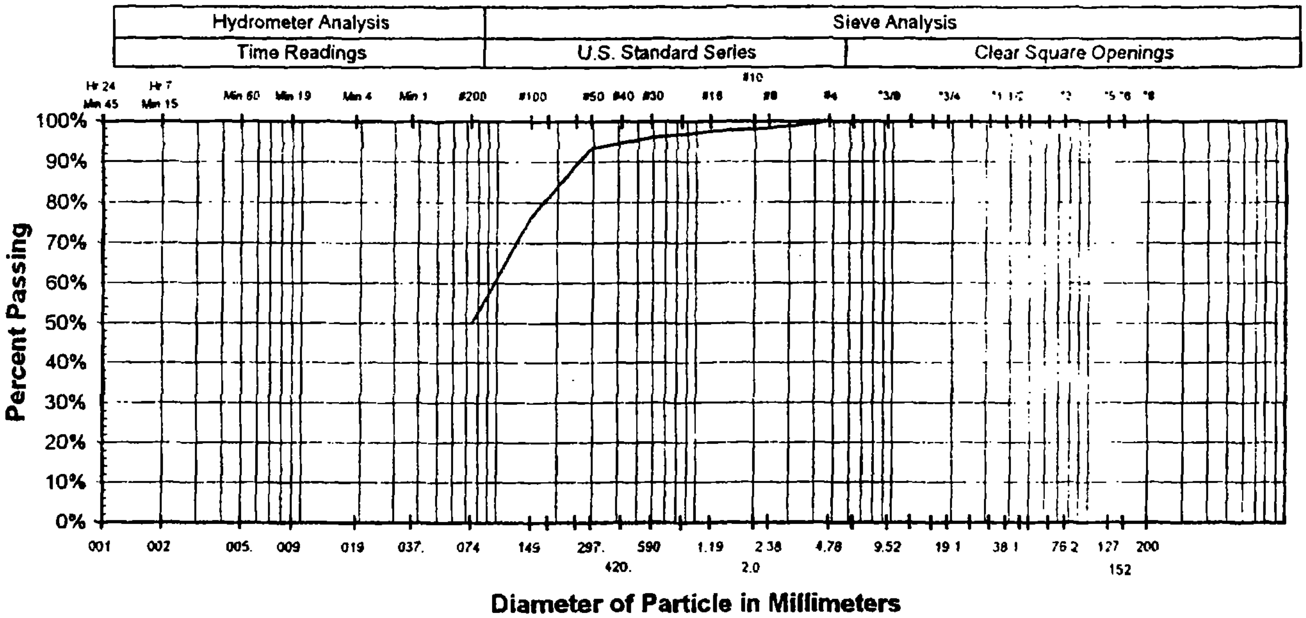
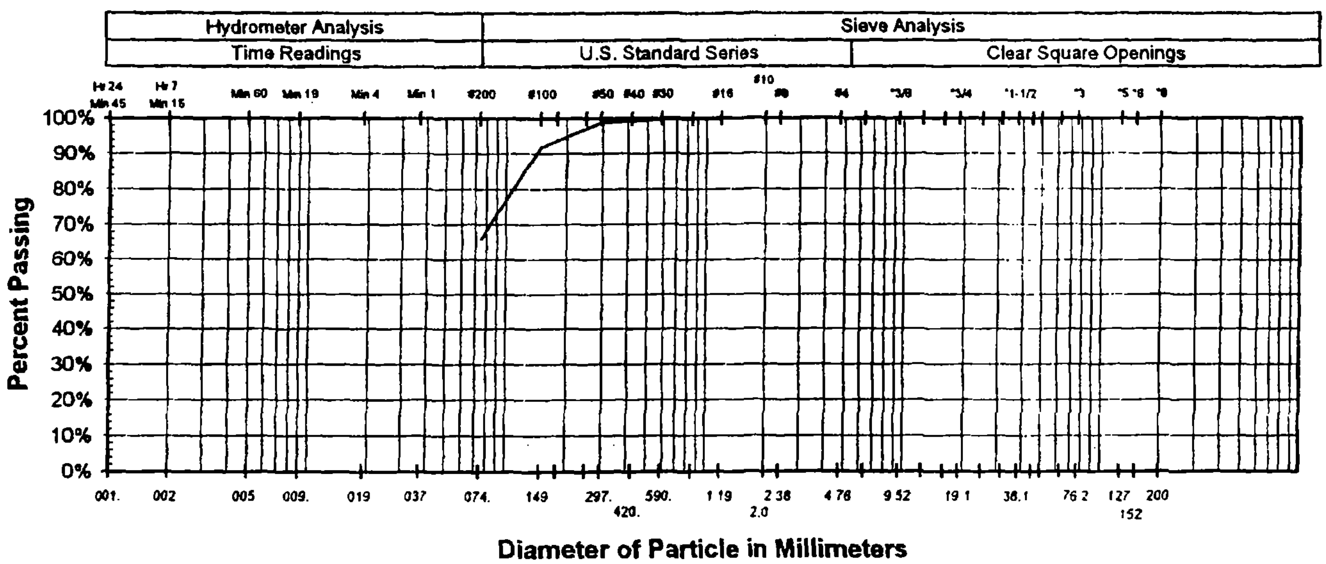


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel 0%
Sand 50%
Silt and Clay 50%
Sample Description Sandy Silt

Liquid Limit -
Plasticity Index -
Sample Location B-4 @ 14'



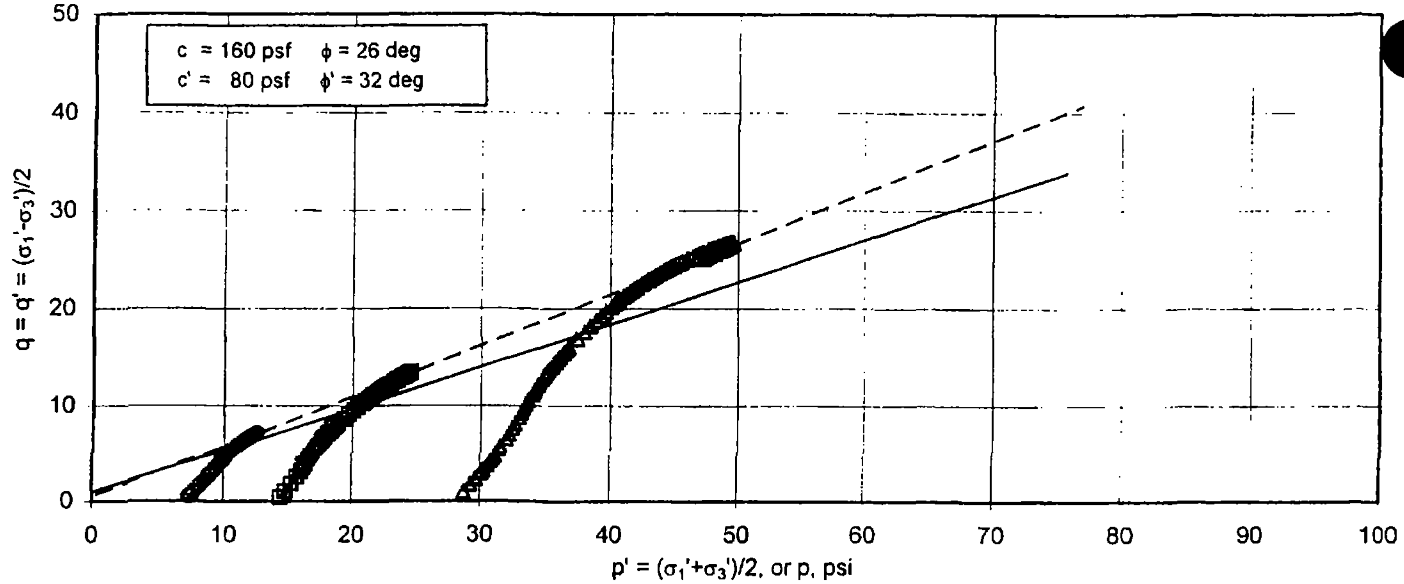
Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

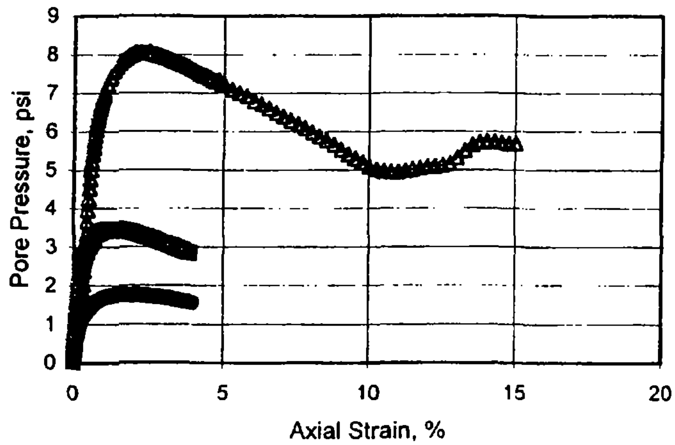
Gravel 0%
Sand 34%
Silt and Clay 66%
Sample Description Sandy Silt

Liquid Limit -
Plasticity Index -
Sample Location B-4 @ 19'

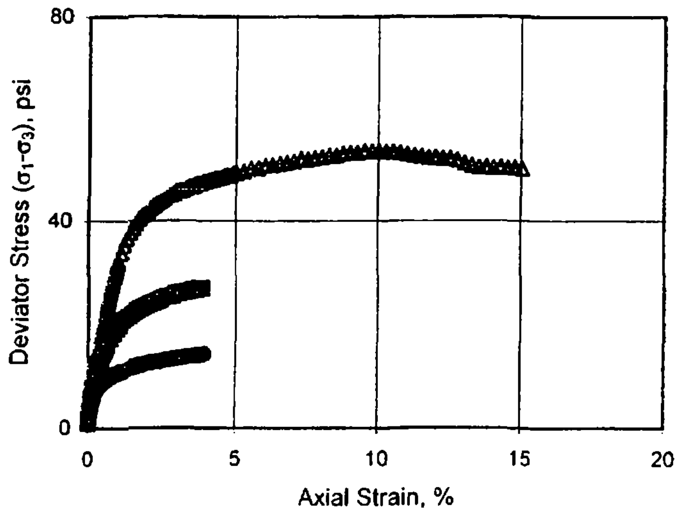
Project No. 1040644 **GRADATION TEST RESULTS** Figure 7

Applied Geotechnical Engineering Consultants, P.C.





Test No. (Symbol)	O	□	Δ
Sample Type	undisturbed		
Length, in.	4.00	3.83	3.72
Diameter, in.	1.93	1.76	1.65
Dry Density, pcf	91	N/A	N/A
Moisture Content, %	9	N/A	N/A
Consolidation Pressure, psi	6.9	13.9	27.8
"B" Parameter	0.96	0.96	0.96
Total Confining Stress (σ_3), psi	6.9	13.9	27.8
Total Axial Stress (σ_1), psi	20.3	39.9	73.7
Deviator Stress (σ_1-σ_3), psi	13.4	26.0	45.9
Effective Lateral Stress (σ_3'), psi	5.2	10.8	19.9
Effective Axial Stress (σ_1'), psi	18.6	36.8	65.8
Pore Pressure (μ), psi	1.7	3.1	7.9
Strain, %	3.0	3.0	3.0
Remarks	Multistage Test (CU) Consolidated		
Undrained with pore pressure measurements.			
Sample saturated with back pressure saturation.			



Sample Index Properties	
Natural Dry Density, pcf	91
Natural Moisture Content, %	9
Liquid Limit, %	
Plasticity Index, %	non-plastic
Percent Gravel	0
Percent Sand	44
Percent Passing No. 200 Sieve	56

Sample Description Sandy Silt

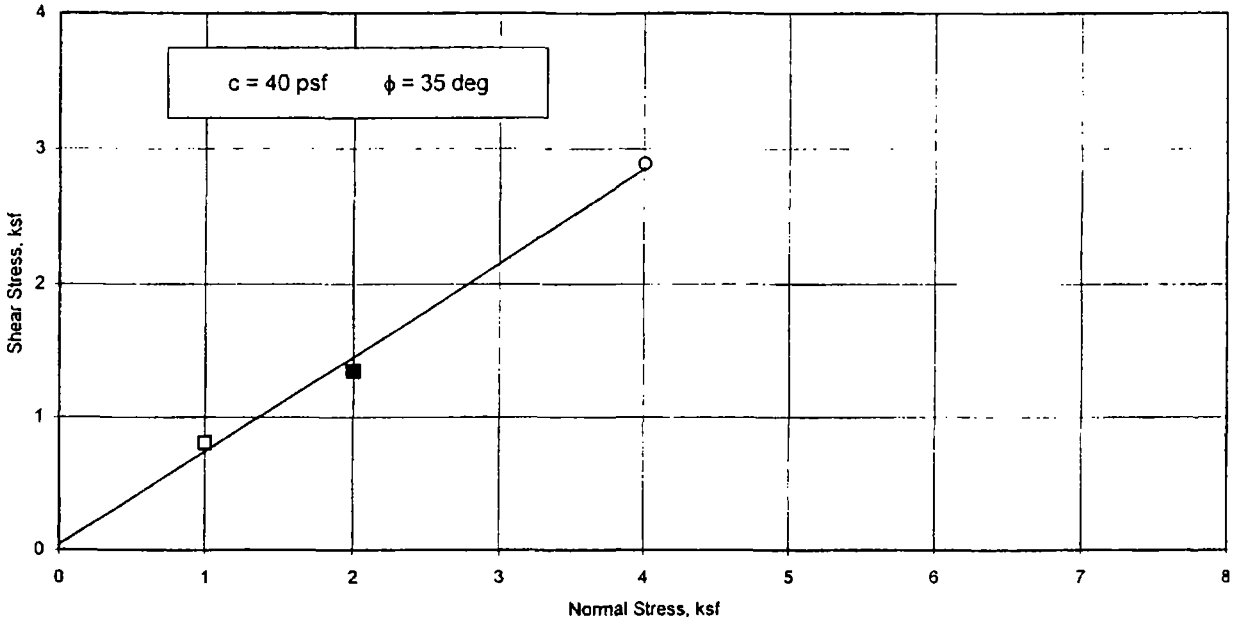
Sample Location B-4 @ 24'

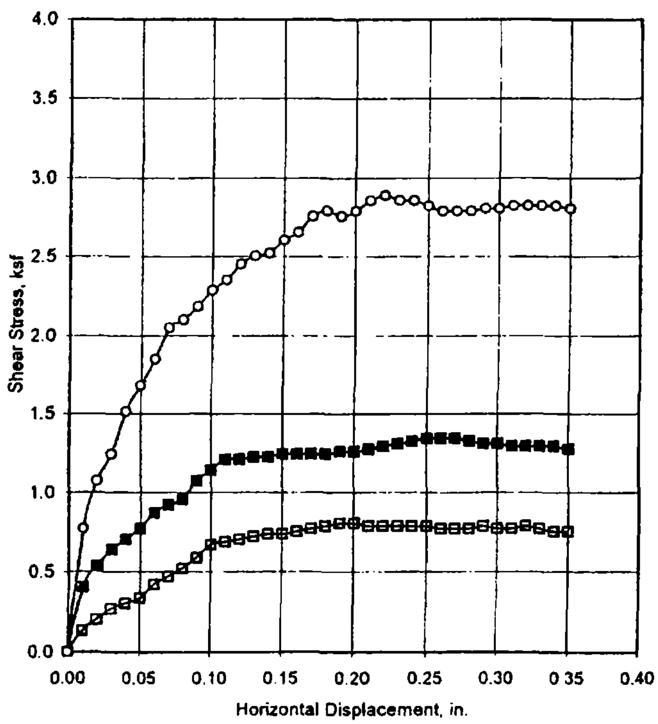
Project No. 1040644

Triaxial Compression Test Results

Figure 8

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.81	1.35	2.89
Remarks	Strain Rate 0.05 in/min.		

Sample Index Properties	
Dry Density, pcf	87
Moisture Content, %	13
Liquid Limit, %	
Plasticity Index, %	
Percent Gravel	11
Percent Sand	35
Percent Passing No. 200 Sieve	54

Type of Test: Consolidated Wetted

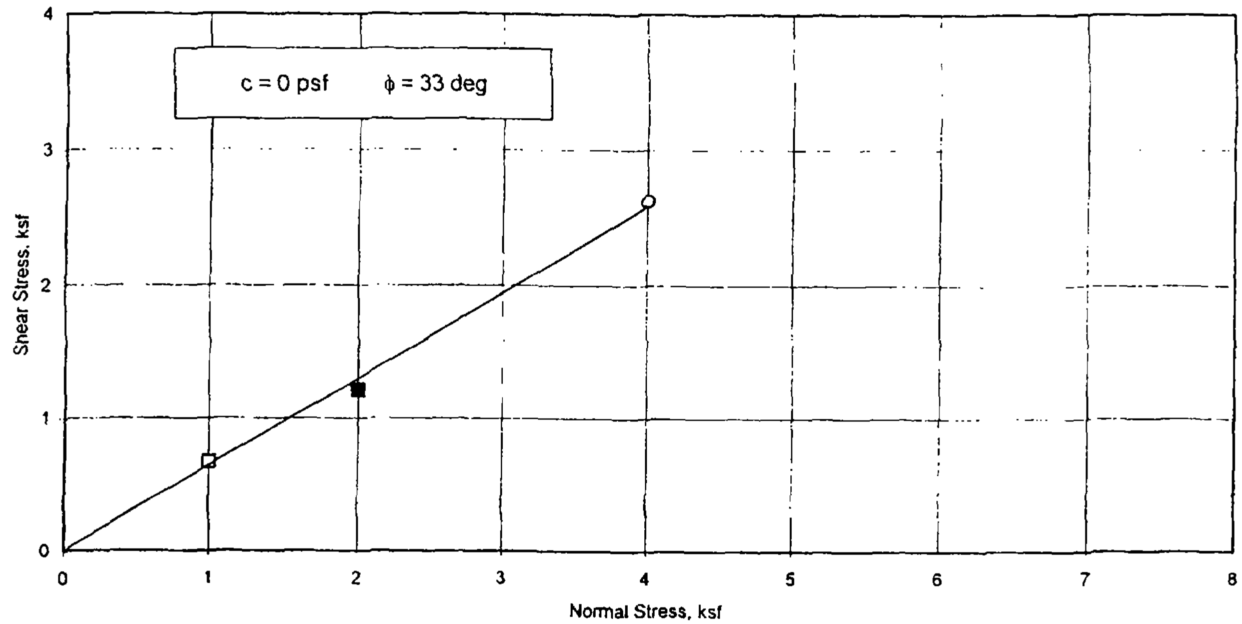
Sample Description: Sandy Silt   From: B-2 @ 34'

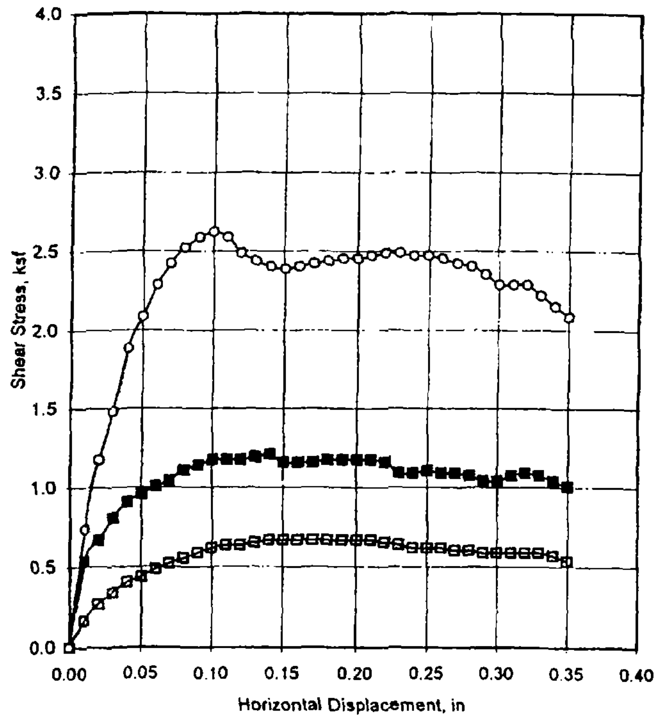
Project No. 1040644

Direct Shear Test Results

Figure 9

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.67	1.21	2.62
Remarks	Strain Rate 0.05 in/min		

Sample Index Properties	
Dry Density, pcf	103
Moisture Content, %	5
Liquid Limit, %	
Plasticity Index, %	
Percent Gravel	0
Percent Sand	92
Percent Passing No. 200 Sieve	8

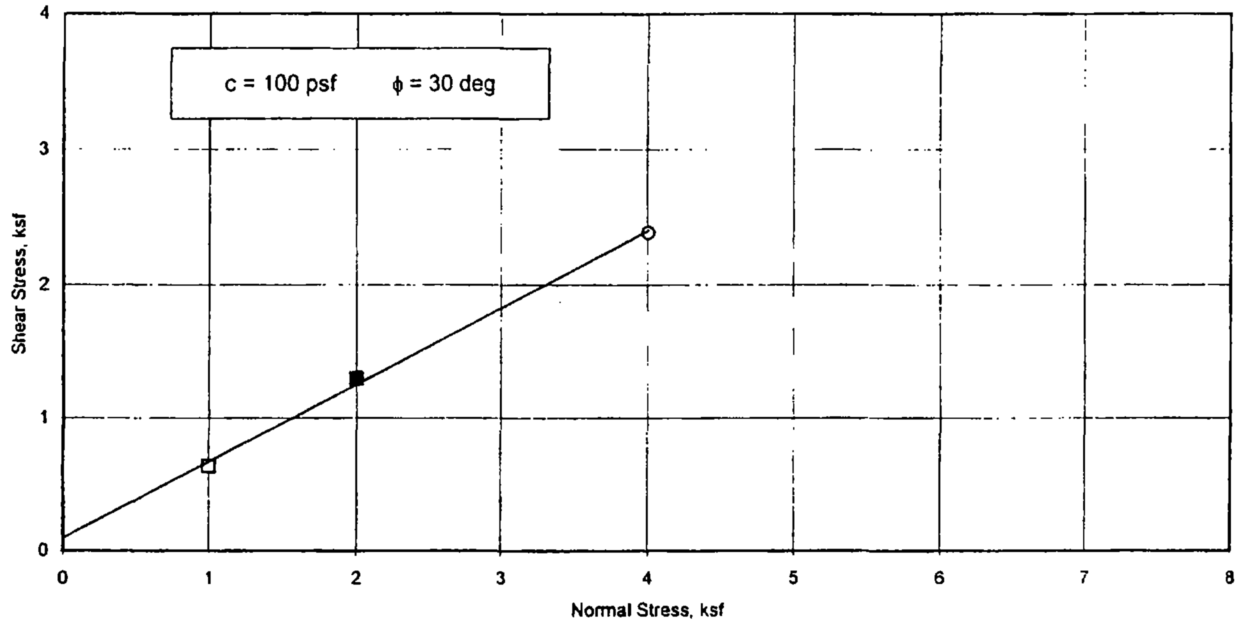
Type of Test: Consolidated Wetted
Sample Description: Poorly Graded Sand with Silt From: B-3 @ 14'

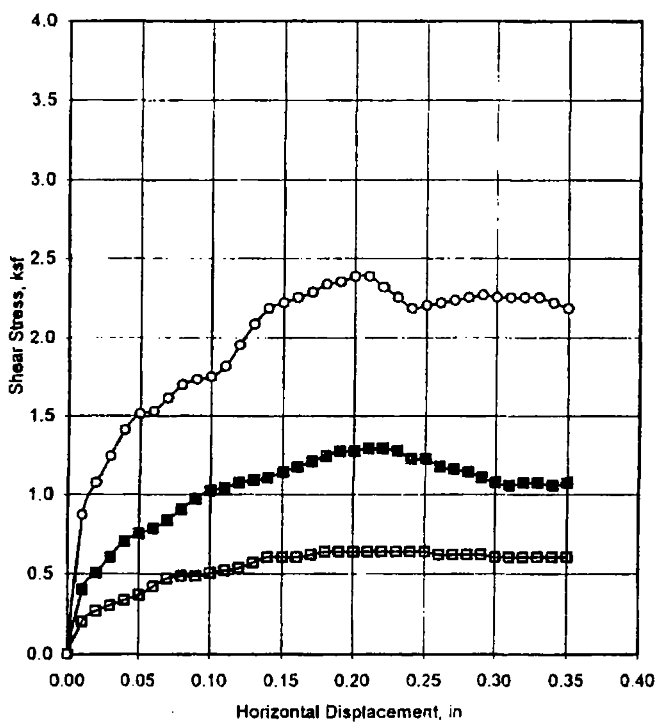
Project No. 1040644

Direct Shear Test Results

Figure 10

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.64	1.29	2.39
Remarks	Strain Rate 0.05 in/min.		

Sample Index Properties	
Dry Density, pcf	90
Moisture Content, %	9
Liquid Limit, %	
Plasticity Index, %	
Percent Gravel	0
Percent Sand	50
Percent Passing No. 200 Sieve	50

Type of Test: Consolidated Wetted

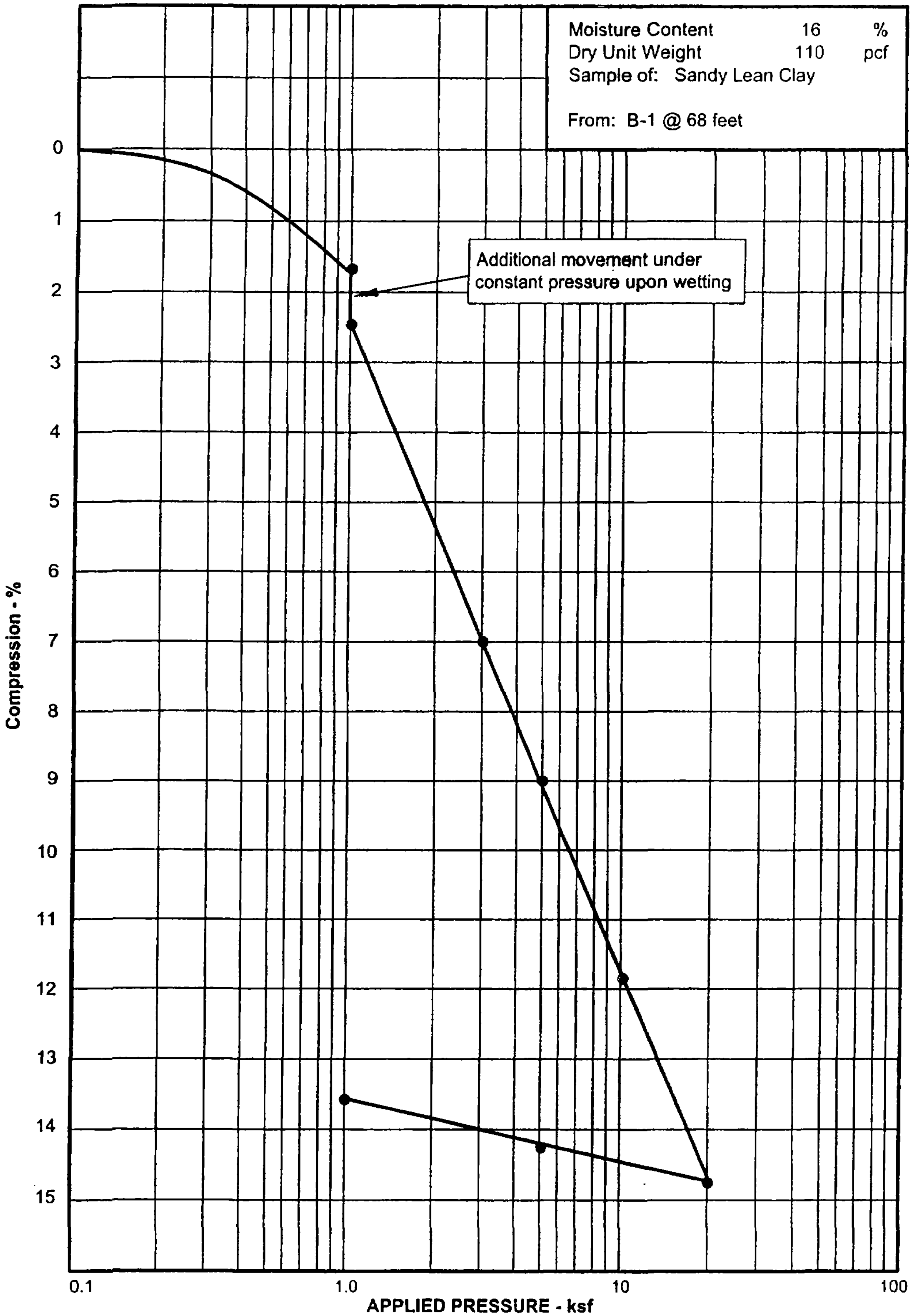
Sample Description: Sandy Silt From B-4 @ 14'

Project No. 1040644

Direct Shear Test Results

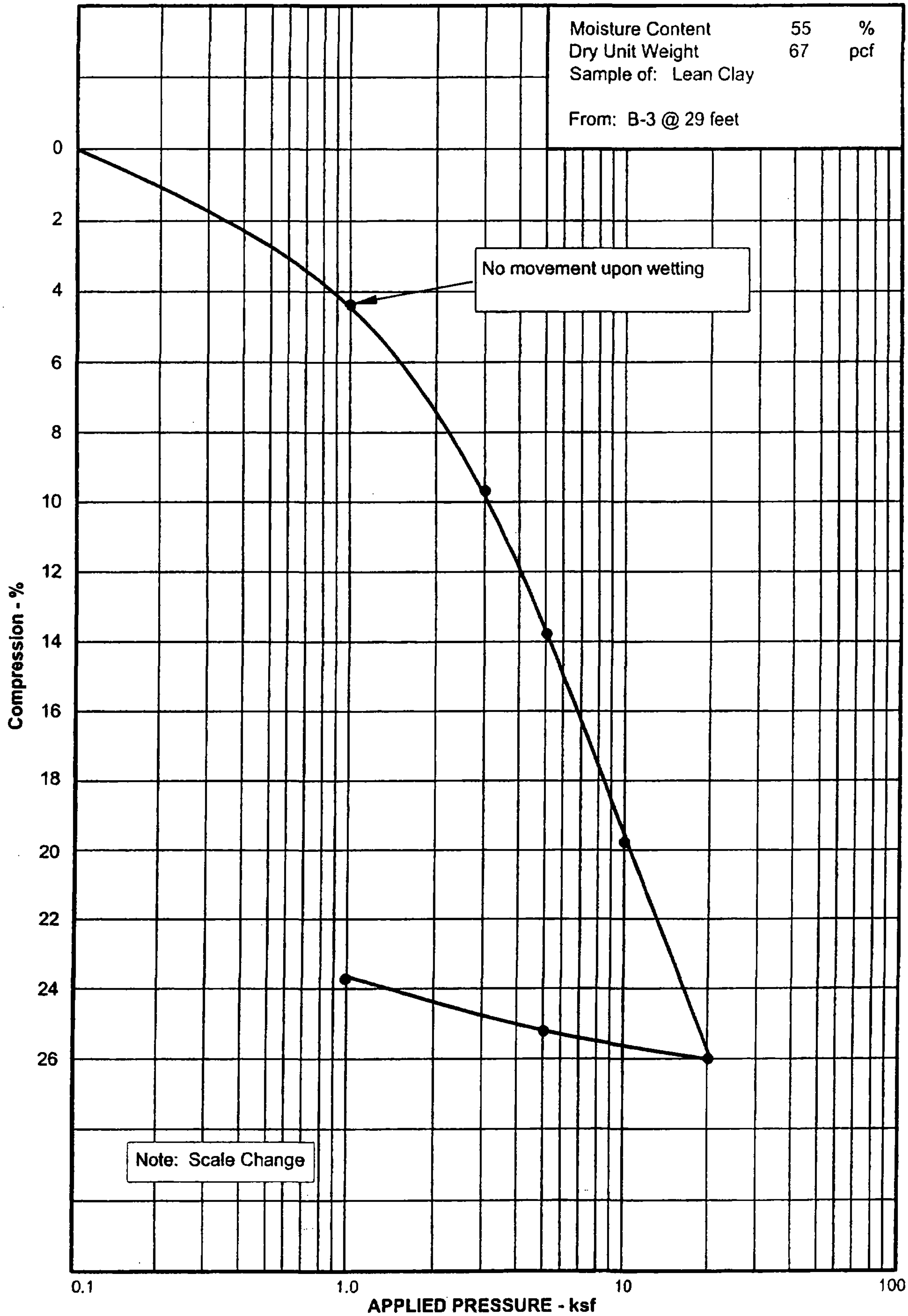
Figure 11

Applied Geotechnical Engineering Consultants, P.C.



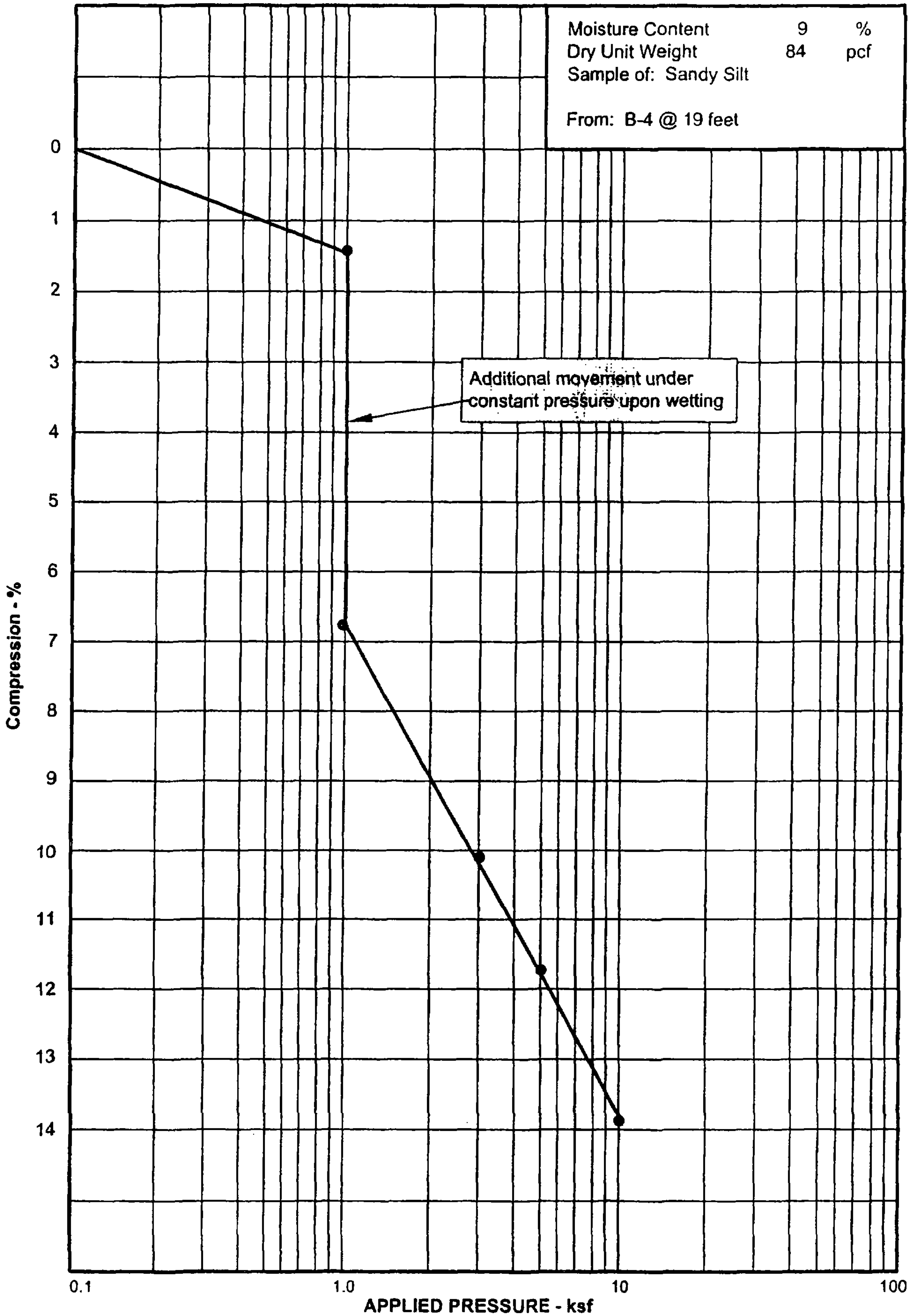
Project No. 1040644 CONSOLIDATION TEST RESULTS Figure 12

Applied Geotechnical Engineering Consultants, P.C.



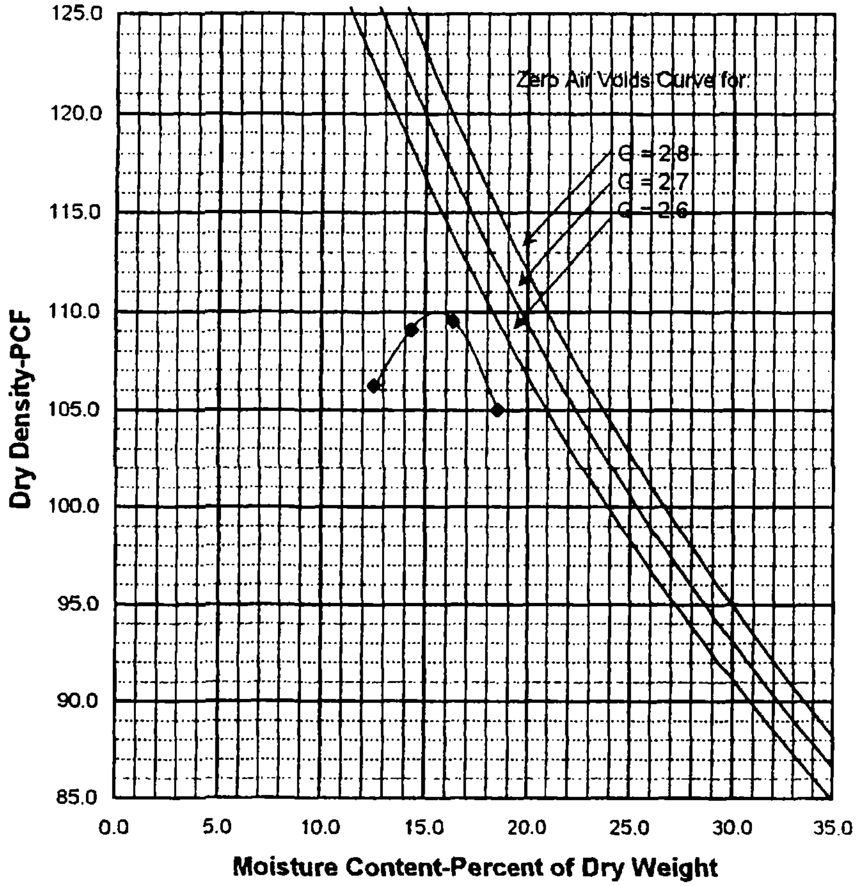
Project No. 1040644 CONSOLIDATION TEST RESULTS Figure 13

Applied Geotechnical Engineering Consultants, P.C.

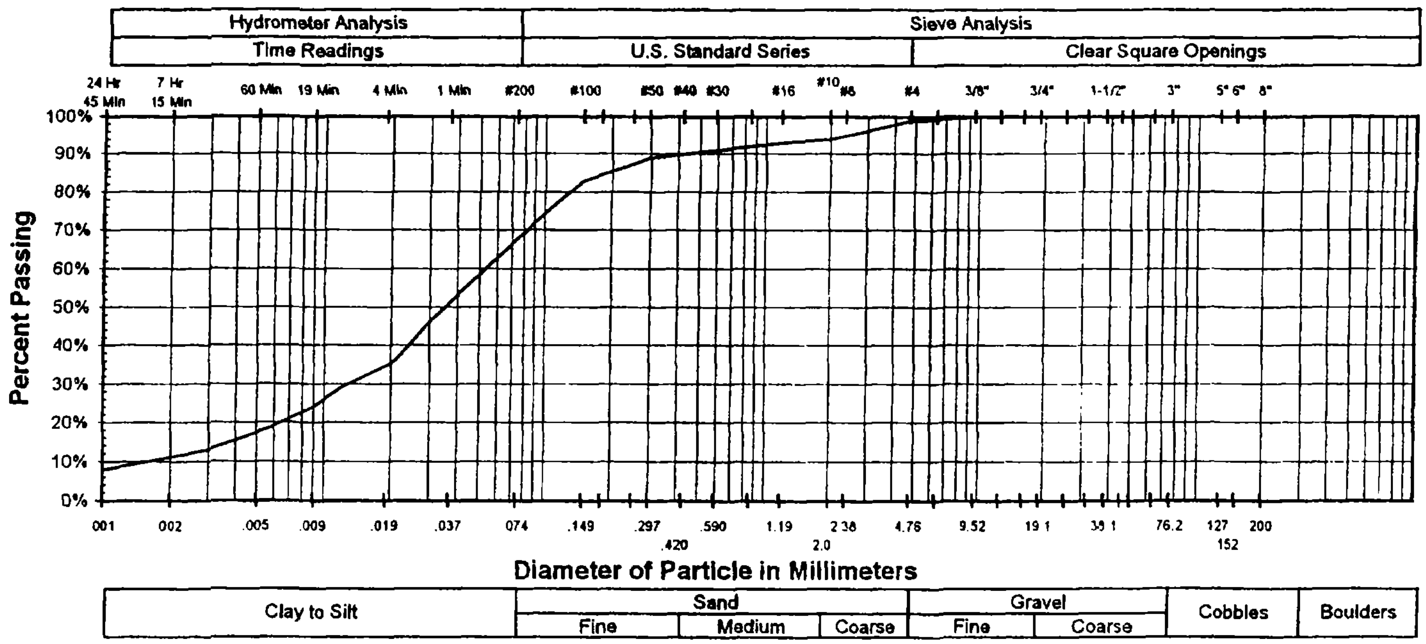


Project No. 1040644 **CONSOLIDATION TEST RESULTS** **Figure 14**

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.



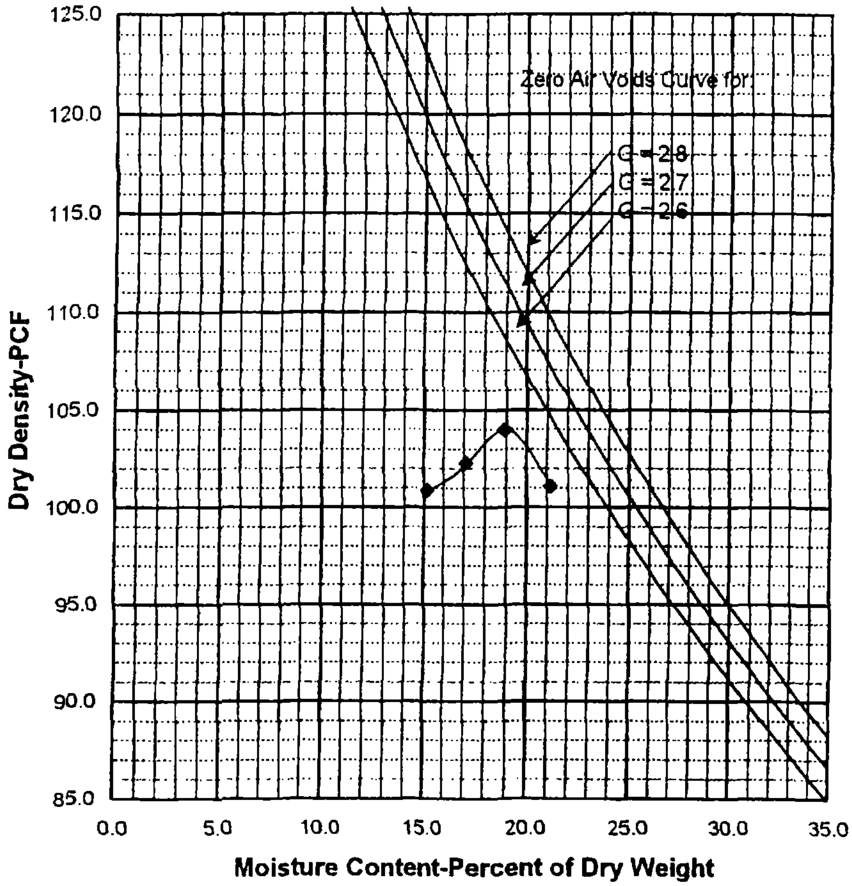
Project	Wasatch Regional	
Project No.	1040644	
Sample No.	A	
Maximum Dry Density		110 pcf
Optimum Moisture		15.5%
Atterberg Limits		
Liquid Limit		22%
Plasticity Index		6%
Gradation		
Gravel		1%
Sand		60%
Silt & Clay		39%
Reviewed By:	JS	
Test Procedure:	ASTM D698 A	
Sample Location:	NW Corner	
Description:	Silty Clayey Sand	



GRADATION &
MOISTURE-DENSITY RELATIONSHIP

Figure 15

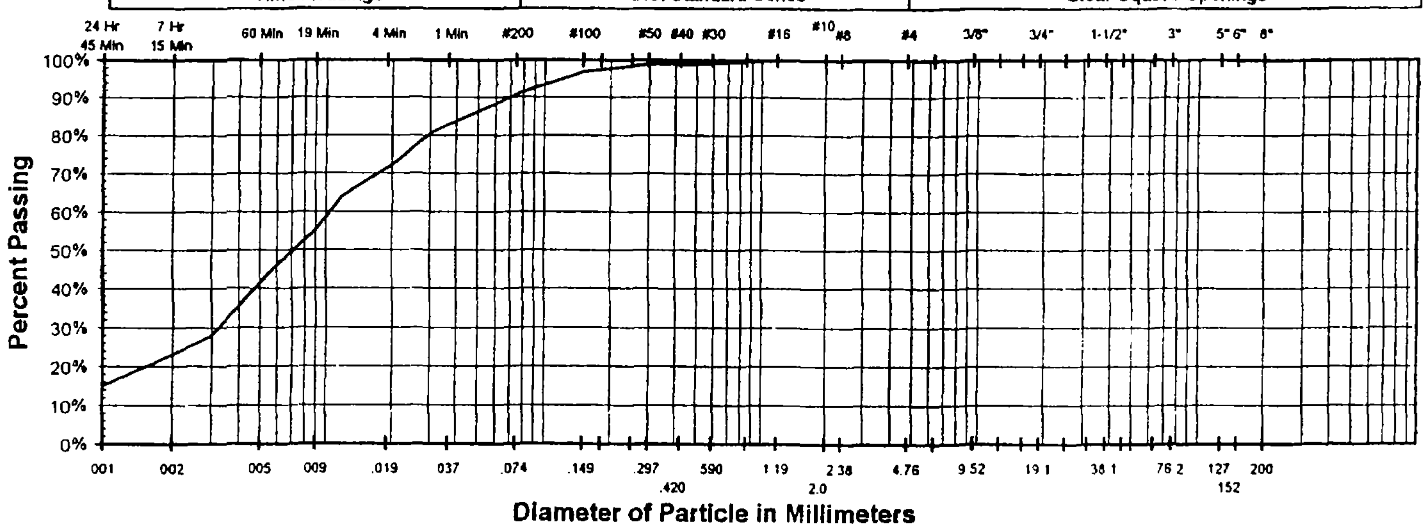
APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.



Project	Wasatch Regional	
Project No.	1040644	
Sample No.	B	
Maximum Dry Density		104 pcf
Optimum Moisture		19%
Atterberg Limits		
Liquid Limit		18%
Plasticity Index		1%
Gradation		
Gravel		0%
Sand		9%
Silt & Clay		91%

Reviewed By: JS
Test Procedure: ASTM D698 A
Sample Location: Midpoint South Side

Description: Silt

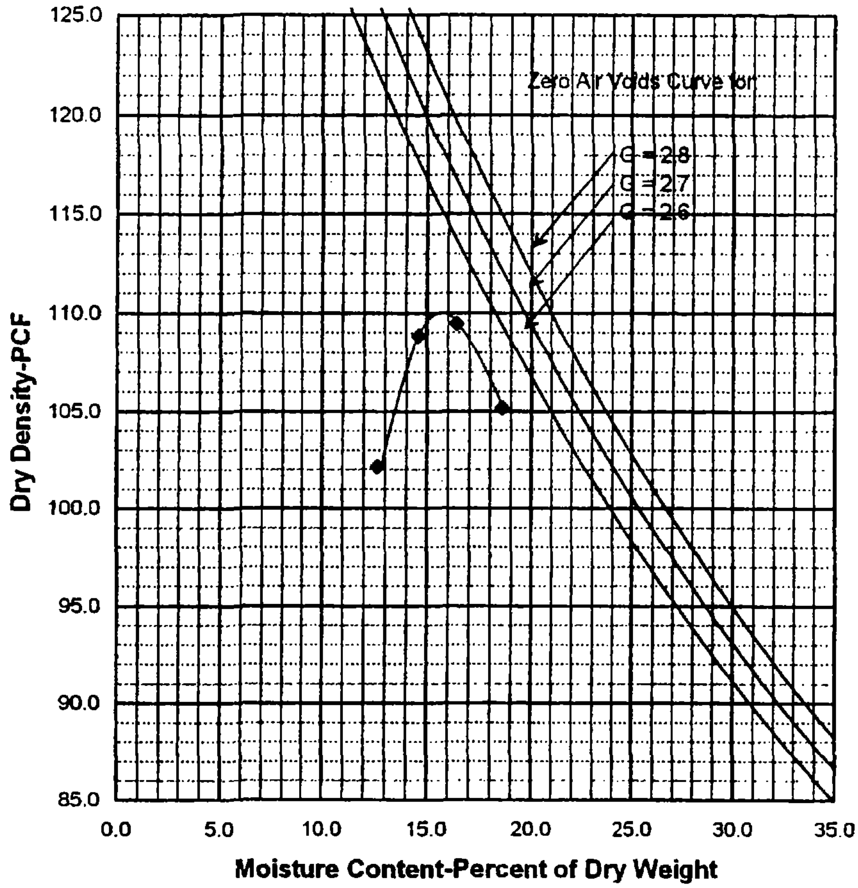


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

GRADATION & MOISTURE-DENSITY RELATIONSHIP

Figure 16

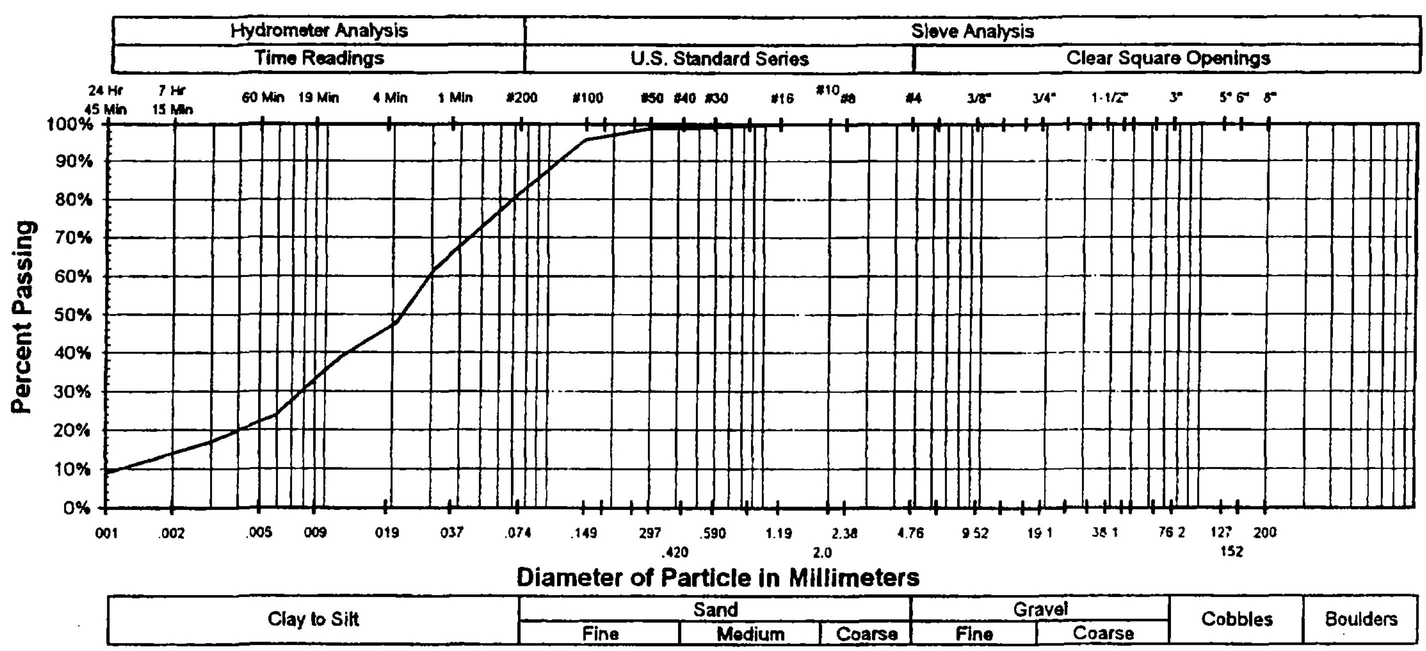
APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.



Project	Wasatch Regional	
Project No.	1040644	
Sample No.	C	
Maximum Dry Density		110 pcf
Optimum Moisture		15.5%
Atterberg Limits		
Liquid Limit		22%
Plasticity Index		6%
Gradation		
Gravel		0%
Sand		18%
Silt & Clay		82%

Reviewed By: JS
Test Procedure: ASTM D698 A
Sample Location: B-3

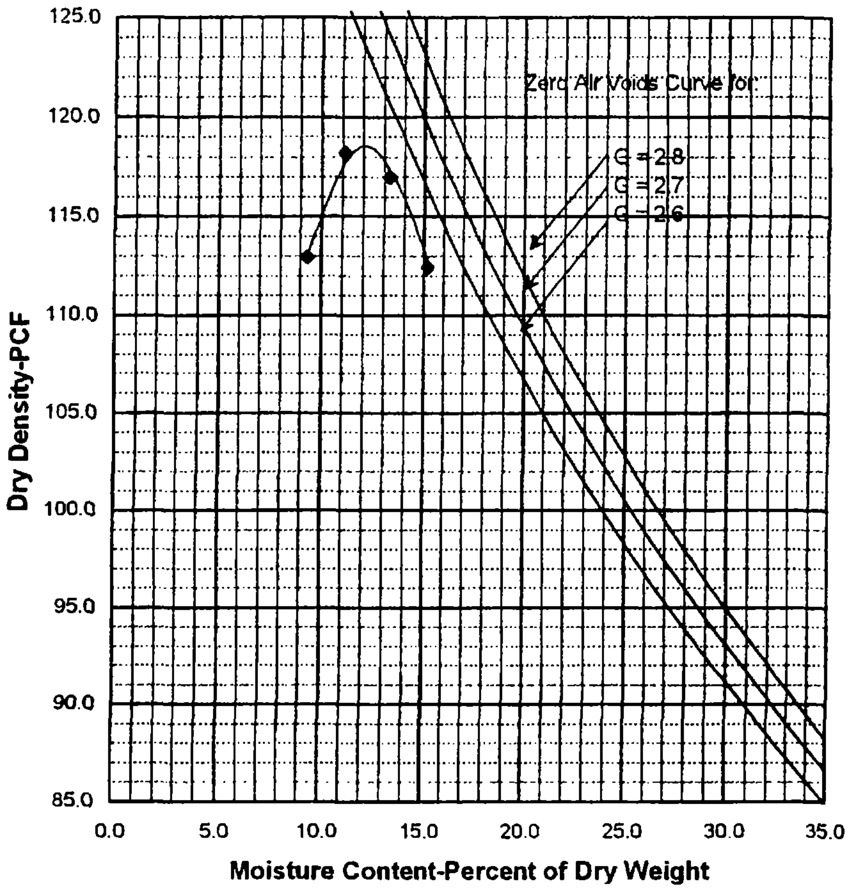
Description: Silty Clay with Sand



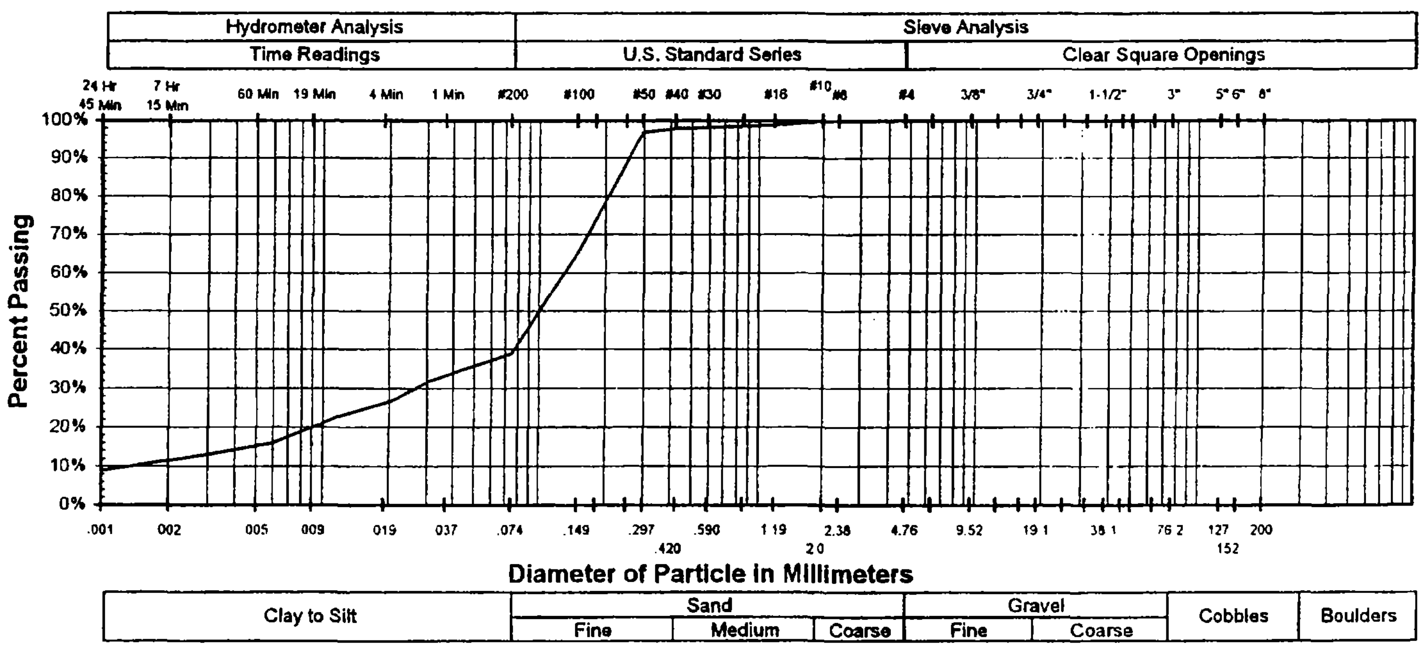
GRADATION & MOISTURE-DENSITY RELATIONSHIP

Figure 17

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

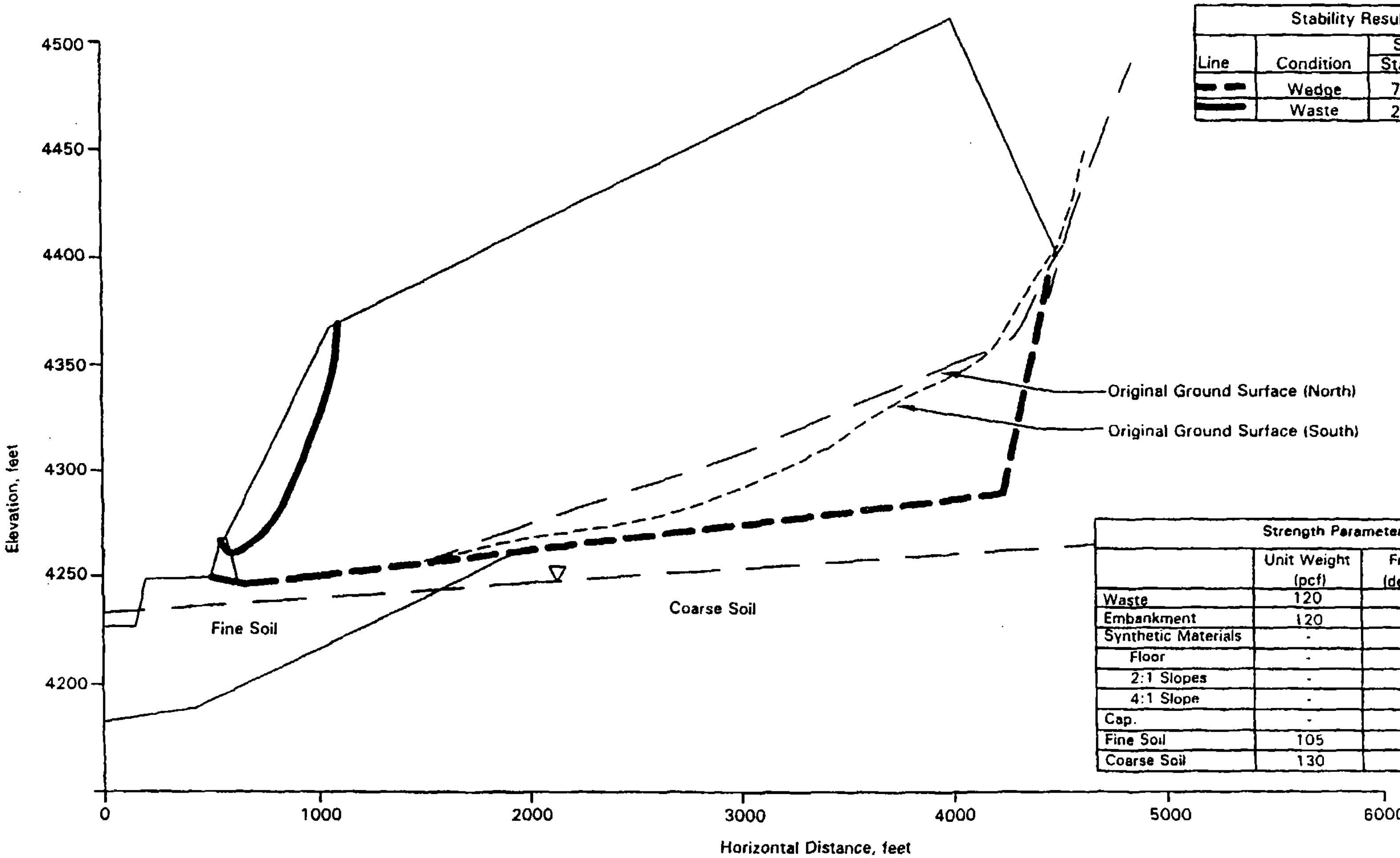


Project	Wasatch Regional	
Project No.	1040644	
Sample No.	D	
Maximum Dry Density		118.5 pcf
Optimum Moisture		12%
Atterberg Limits		
Liquid Limit		17%
Plasticity Index		2%
Gradation		
Gravel		0%
Sand		61%
Silt & Clay		39%
Reviewed By:	JS	
Test Procedure:	ASTM D698 A	
Sample Location:	B-3	
Description:	Silty Sand	



GRADATION & MOISTURE-DENSITY RELATIONSHIP

Figure 18



Stability Results

Line	Condition	Safety Factor Static	Safety Factor Seismic
(heavy dashed)	Wedge	7.1	1.4
(heavy solid)	Waste	2.3	1.6

Strength Parameters

	Unit Weight (pcf)	Friction (degrees)	Cohesion (pcf)
Waste	120	25	100
Embankment	120	32	300
Synthetic Materials	-		
Floor	-	8	0
2:1 Slopes	-	23.9	95
4:1 Slope	-	23.9	95
Cap.	-	21.4	84
Fine Soil	105	31	40
Coarse Soil	130	37	0

1040644	ARES	Stability Section A-A" and B-B'	Figure 19

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1040644

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (ppm)	SAMPLE CLASSIFICATION
BORING/ TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
B-1	68	16	110			56	40	26			Sandy Lean Clay
B-2	34	13	87	11	35	54					Sandy Silt
B-3	14	5	103	0	92	8					Poorly Graded Sand with Silt
	29	55	67			87	43	19			Lean Clay
	34	21	107			56	21	7			Sandy Silty Clay
B-4	14	9	90	0	50	50					Sandy Silt
	19	9	84	0	34	66					Sandy Silt
	24	9	91	0	44	56		NP			Sandy Silt
B-5	29	28	94			28		NP			Silty Sand
	34	40	79			88	44	23			Lean Clay

APPENDIX 1

Soil Characteristics

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/9/04 BY [illegible]

SUBJECT Soil Characteristics SHEET 1 OF 6

Kleinfelder Study (May 18, 2004 - Proj. #35467.003

Compressibility

Boring	Depth	Cr'	Cc'	mpf	Description
B-2	5'	0.018	0.177	900	Lean Clay w/Sand
B-3	7 1/2'	0.014	0.065	7000	Sandy Lean Clay
B-4	15'	0.022	0.064	2000	Sandy Lean Clay
B-5	7 1/2'	0.007	0.108	5000	Sandy Silty Clay
B-9	8'	0.015	0.081	4000	Clayey Sand
B-9	30'	0.022	0.118	4200	Elastic Silt
B-11	10'	0.010	0.165	2200	Silt w/sand

Consolidation

Boring	Depth	Load	Cv	Load	Cv
B-2	5'	4 ksf	12.4 ft²/day	8 ksf	10.1 ft²/day
B-4	15'	4	2.6	8	12.5
B-9	8'	2	14.6	4	13.4
B-9	30'	4	13.2	8	10.1
B-11	10'	2	13.1	4	9.3

Strength

Undisturbed

B-11 @ 10' Unconfined = 3580 psf (-200 = 79%)

Remolded - Direct Shear

B-2 @ 2' ϕ = 35° C = 550 psf remolded to 95% (ASTM D-698)

B-6 @ 15' 29° 75

B-10 @ 10' 31° 0

} remolded to insitu density

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/9/04 BY [illegible]

SUBJECT Soil Characteristics SHEET 2 OF 6

AGEC Data

Index Properties

		mc	DD	+4	-200	LL	PI
B-1	@ 68	16.3	110.4		56	40	26
B-2	@ 34	12.8	86.6	11	54		
B-3	@ 14	4.7	102.5	0	8		
B-3	@ 29	54.7	66.9		97	43	19
	@ 34	20.6	106.5		56	21	7
B-4	@ 14	8.6	89.7	0	50		
	@ 19	9.3	84.0	0	66		
	@ 24	8.9	91.2				

Compression

Boring	Depth	Cr	Cc'	mpp	Other	Desc.
B-1	68	0.01	0.081		1.0% C.	Sandy Lean Clay
B-3	29	0.008	0.101	2000	-	Lean clay
B-4	19		0.070		5.2%	Collapse Sandy Silt

Strength

Direct Shear

B-2 @ 34	$\phi = 35°$	c = 40 psf	a little gravel
B-3 @ 14	$\phi = 33°$	c = 0	
B-4 @ 14	$\phi = 30°$	c = 100 psf	Silt + Sand

Triaxial Shear

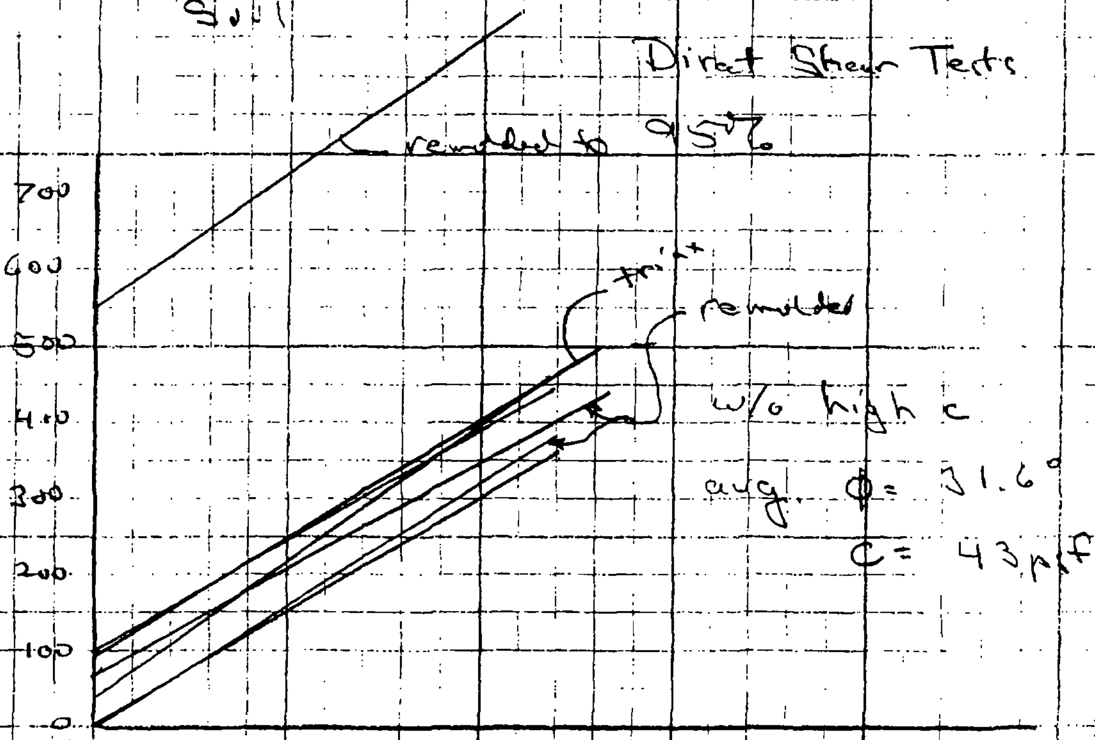
B-4 @ 24	$\phi' = 32°$	c' = 80 psf
	$\phi = 26$	c = 160 psf

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/9/04 BY [illegible]

SUBJECT Soil Characteristics SHEET 3 OF 6

Fine Grained Soil



w/o high c

avg. $\phi = 31.6°$

$c = 43$ psf

Granular Soil

$N_{1(60)}$ avg = 35 Kleinfelder
49 AGEC (we were up the hill further)

Using 35 ⇒ $\phi = 37°$

Comparing the remolded strengths (35 & 550) with the literature –

use $\phi = 32°$ & $c = 300$ psf.

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/9/04 BY [illegible]

SUBJECT Soil Characteristics SHEET 4 OF 6

Unit Weights

Kleinfelder

(SM/SC)		(CL/ML)		(GM)	
15%	87 pcf	41%	77 pcf	1%	132 pcf
27	97	17	~~88~~		
16	112	15	87		
7	82	11	94		133 pcf
12	94	46	72		
7	100				
21	107	avg.	103.5		
16	117				
7	96				
20	105				
2	103				
2	106				
15	106				
17	112				
avg.	115 pcf				

AGEC

		16	110
5	103	13	87
108.2		65	67
		21	107
		9	90
		9	84
		9	91
		avg.	106.9

overall

$$\frac{(115)(14) + 108}{15}$$

114.5 pcf

$$\frac{(103.5)(5) + (106.9)(7)}{12}$$

105.5 pcf

1040644

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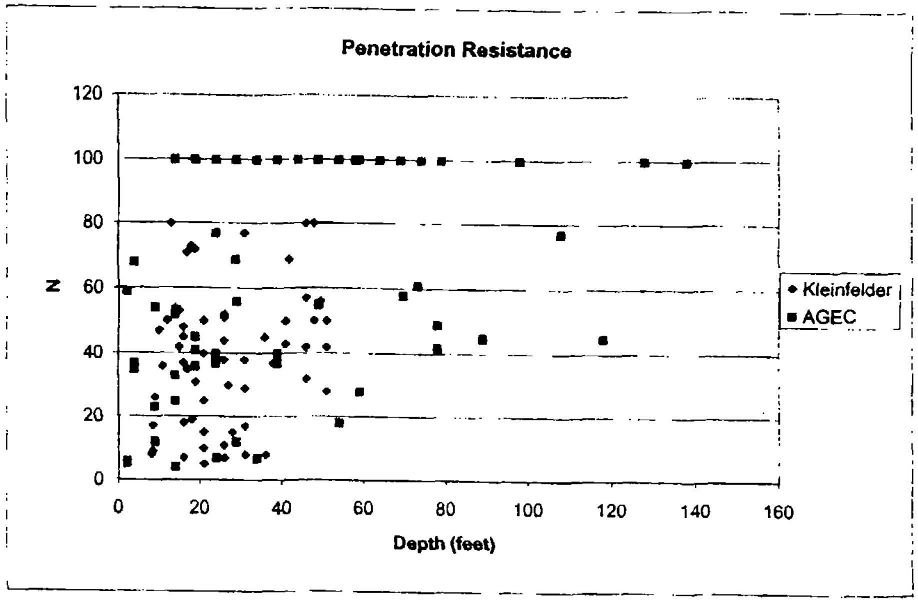
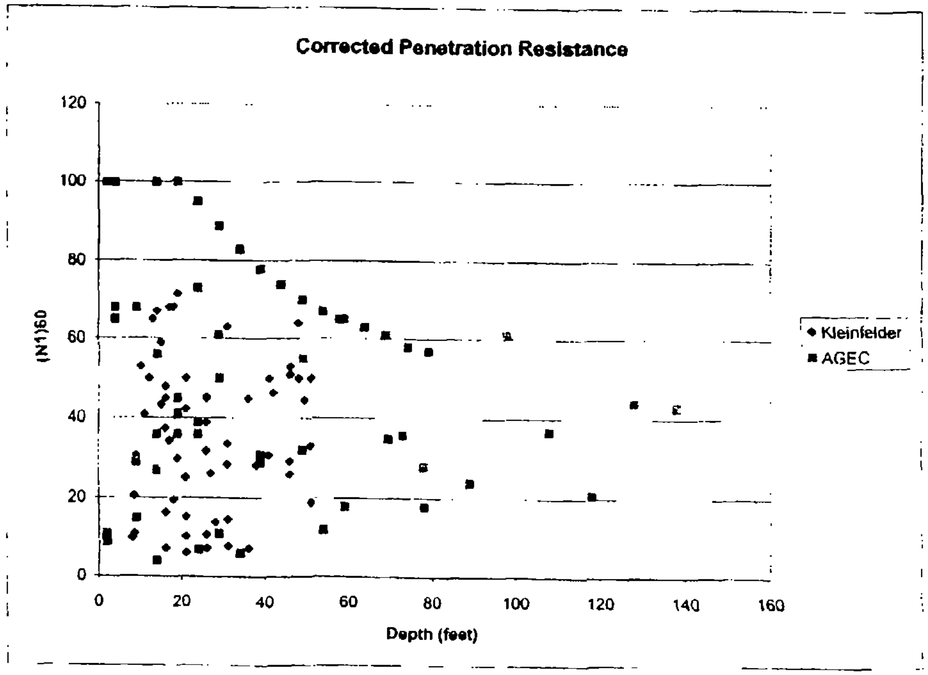
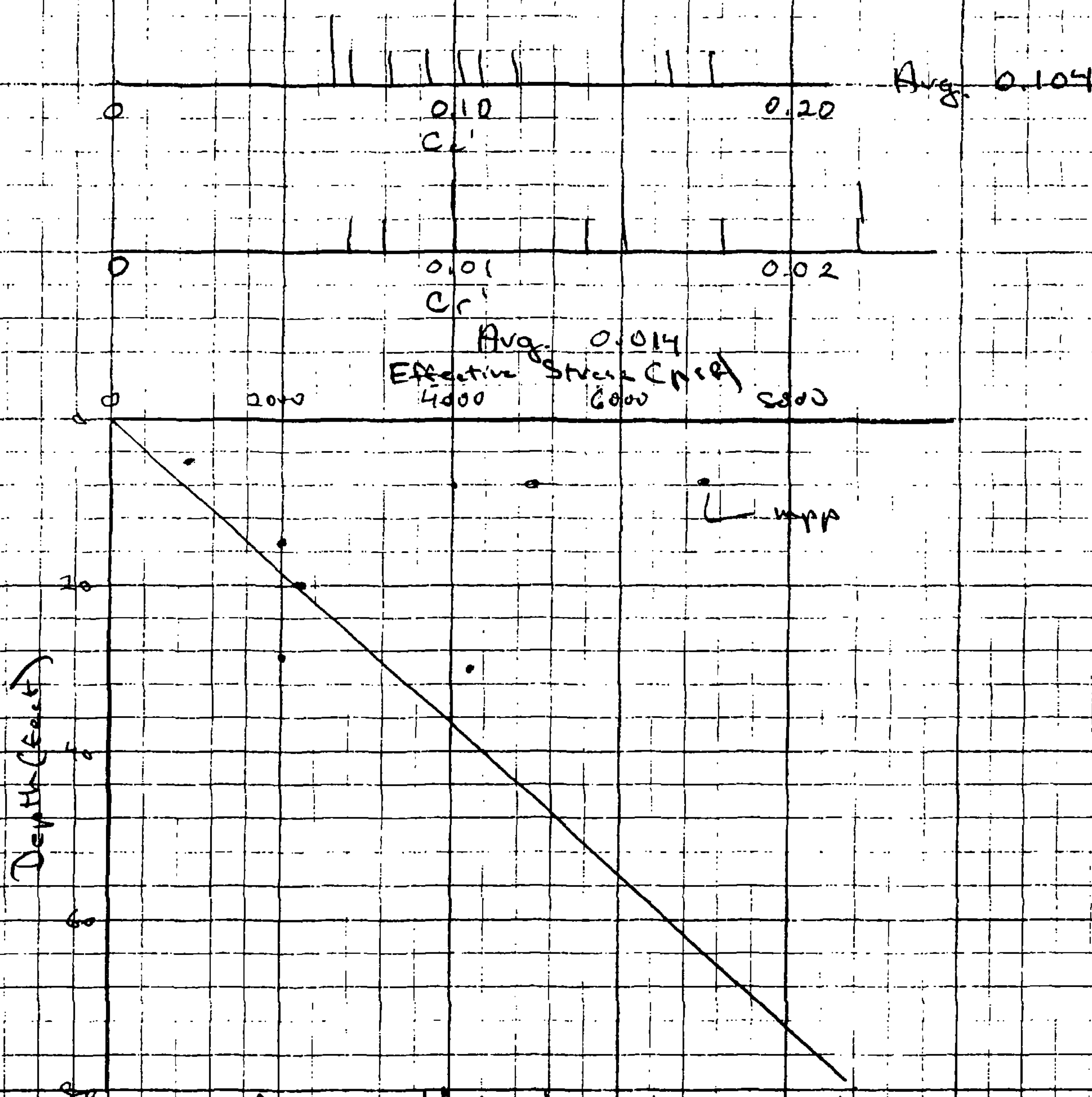
	Kleinfelder				AGEC		
Boring	Depth	N (raw)	(N1)60	Boring	Depth	N (raw)	(N1)60
1	8.5	17	20.6	1	2	59	100
	16	37	37.5		4	37	68
	21	40	42.2		9	23	29
	26	7	7.3		14	100	100
	51	50	50		19	36	36
2	8.5	9	11		24	100	95
	18	19	19.5		29	69	61
	49.5	56	44.5		34	100	83
3	21	25	25.3		39	100	78
	26	11	10.8		49	55	32
	31	8	7.9		58	100	65
	46	32	26		78	49	28
4	21	50	50		89	45	24
	26	44	38.9		98	100	61
	31	38	33.7		108	77	37
5	16	7	7.3		118	45	21
	21	10	10.3		128	100	44
	36	45	44.9		138	100	43
	41	50	50	2	4	68	100
	46	42	29.3		9	54	68
6	21	5	6.2		14	52	56
	27	30	26.2		19	100	100
	31	77	63.1		24	77	73
	42	69	46.4		29	56	50
7	8	8	9.9		34	7	6
	16	18	16.4		39	37	29
	21	15	15.3		44	100	74
	26	38	31.8		49	100	70
	31	17	14.7		54	18	12
	38	37	28.3		59	100	65
	48	50	50		64	100	63
8	11	36	40.9		69	100	61
	16	45	45		74	100	58
	21	25	25		79	100	57
	26	51	44.9	3	14	33	36
9	10	47	53		19	41	41
	12	50	50		24	37	36
	14	54	67	4	2	6	11
	16	48	48		4	35	65
	18	73	68		9	12	15
	28	15	14		14	4	4
	36	8	7.3		24	7	7
	46	57	51		29	100	89
10	9	26	30.7		34	100	83
	13	80	65		39	40	31
	15	42	43.3		44	100	74
	17	71	68		49	100	55
	19	31	29.8		54	100	67
	21	50	50		59	28	18
	31	29	28.5		64	100	63
	48	80	64		69.5	58	35
	51	42	33.1		73	61	36
11	15	53	59		78	42	18
	17	35	34.4	5	2	5	9
	19	72	71.4		14	25	27
	26	52	45.3		19	45	45
	41	43	30.8		24	40	39
	46	80	53.1		29	12	11
	51	28	18.9				





Characteristics for analysis.

Avg. γ clay-silt 107.0



Appears that there is no maximum past pressure

APPENDIX 2

Bearing Capacity

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT Bearing Capacity SHEET 1 OF 2

A Load applied - Embankment

Embankment (4265 - 4244) = 21 ft high

Load is (21 ft)(105 pcf) = 2205 psf

Bearing Capacity

Undrained = $\left(\frac{3580 \text{ psf}}{2}\right)(5.12) = 9165 \text{ psf}$

$$S.F. = \frac{9165 \text{ psf}}{2205 \text{ psf}} = 4.2 \quad \underline{\underline{\text{ok}}}$$

Total Stress

$\phi = 26^\circ$ $c = 160$ psf

$Q_{ult} = 1.2cN_c + (0.4)\gamma B N_\gamma$

$N_c = 20$
$N_\gamma = 7$

$= (1.2)(160)(20) + (0.4)(105)(7)B$

$= 3840 + 294B$

if we assume B = 100 ft

$= 33,240$

$$S.F. = \frac{33,240}{2205} = 15 \quad \underline{\text{ok}}$$

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT Bearing Capacity SHEET 2 OF 2

B. Long term - landfill

Load (260 ft high)(120 pcf) = 31,200 psf

Bearing Capacity.

$\phi = 32$ $c = 80$

$N_\gamma = 18$ $N_c = 30$

$q_{ult} = (1.2)(80 psf)(30) + (0.4)(105)(18) B$

$= 2880 + 756 B.$

in order for S.F. = 3.0

$(31,200)(3) = 2880 + 756 B$

$B \geq 120$ ft. ok

we will be much under

APPENDIX 3

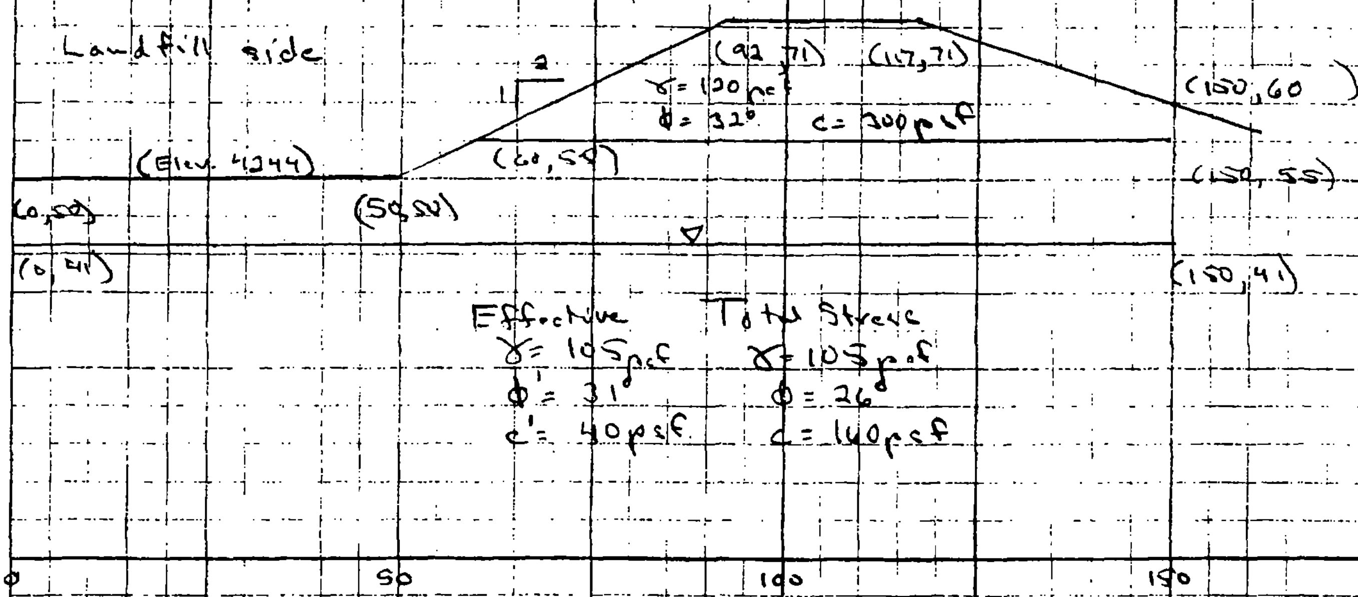
Embankment Stability

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY

SUBJECT Emb. Stability SHEET 1 OF 9

Interior Emb Slope



File Input	Output	Condition	S.F
WRL.in1	WRL.ou1	Static	1.982
WRL.in2	WRL.ou2	Seismic	1.625
WRL.in3	WRL.ou3	Static (Total Stress)	2.055

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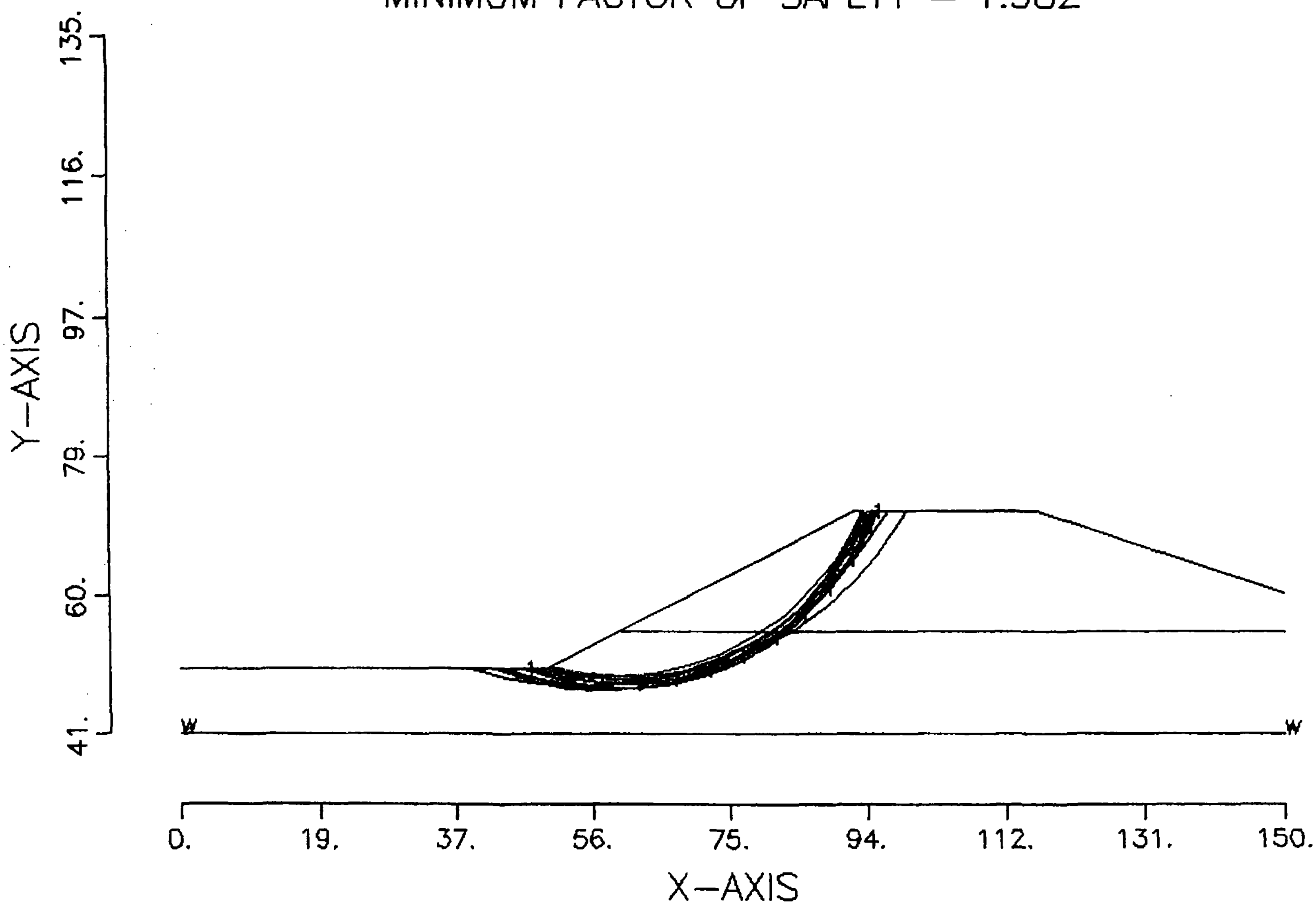
Midvale UT s/n5206

WRL Embankment Stability - Static

2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.982



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****
*****   GeoSlope   *****
*****   Version 5.00   *****
*****   *****
*****   (c)1992 by GEOCOMP Corp, Concord, MA   *****
*****   Licensed to AGEC   *****
****

Problem Title : WRL Embankment Stability - Static
Description :
Remarks :

****
*****   INPUT DATA   *****
****

Profile Boundaries

Number of Boundaries : 6
Number of Top Boundaries : 5

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	50.00	50.00	50.00	2
2	50.00	50.00	60.00	55.00	2
3	60.00	55.00	92.00	71.00	1
4	92.00	71.00	117.00	71.00	1
5	117.00	71.00	150.00	60.00	1
6	60.00	55.00	150.00	55.00	2

Soil Parameters

Number of Soil Types : 2

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	300.0	32.0	0.00	0.0	1
2	105.0	105.0	40.0	31.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces : 1
Unit Weight of Water : 62.40 pcf
Piezometric Surface No. : 1
Number of Coordinate Points : 2

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	41.00
2	150.00	41.00

1040644

****
*****   TRIAL SURFACE GENERATION   *****
****

Data for Generating Circular Surfaces

Number of Initiation Points : 50
Number of Surfaces From Each Point : 50
Left Initiation Point : 10.00 ft
Right Initiation Point : 55.00 ft
Left Termination Point : 90.00 ft
Right Termination Point : 140.00 ft
Minimum Elevation : 1.00 ft
Segment Length : 5.00 ft
Positive Angle Limit : 0.00 deg
Negative Angle Limit : 0.00 deg

****
*****   RESULTS   *****
****

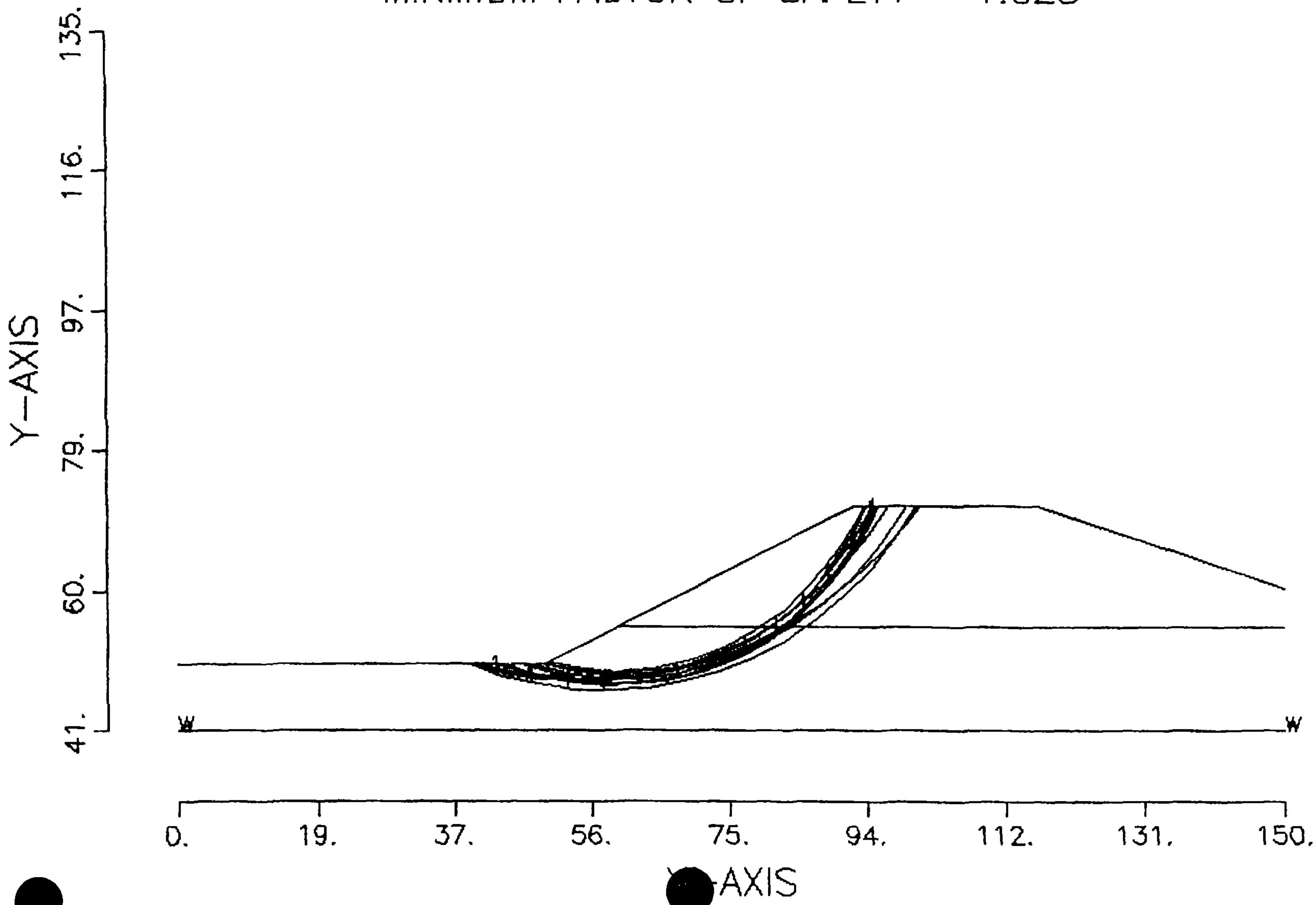
Surface No. : 1
Factor of Safety : 1.982
Circle Center X : 60.18 ft
Circle Center Y : 86.31 ft
Circle Radius : 38.41 ft

Slice	X (ft)	Y (ft)	Width (ft)	Weight (lbs)	Load (lbs)	Water (lbs)	Normal (lbs)	Shear
1	48.83	49.68	2.35	79.1	0.0	0.0	104.0	80.6
2	51.24	49.02	2.48	415.9	0.0	0.0	485.7	199.1
3	54.95	48.34	4.95	2151.3	0.0	0.0	2280.6	792.5
4	58.71	47.99	2.57	1718.1	0.0	0.0	1721.8	574.0
5	61.21	47.98	2.43	1969.2	0.0	0.0	1973.4	647.4
6	64.91	48.28	4.96	4964.9	0.0	0.0	4809.1	1559.2
7	69.81	49.21	4.84	5789.2	0.0	0.0	5520.3	1774.8
8	74.55	50.78	4.64	6100.0	0.0	0.0	5824.9	1867.2
9	79.04	52.95	4.35	5910.4	0.0	0.0	5747.4	1843.7
10	81.76	54.59	1.09	1473.4	0.0	0.0	1484.4	477.7
11	83.76	56.09	2.90	3758.9	0.0	0.0	3467.4	1643.5
12	87.00	58.93	3.57	4099.4	0.0	0.0	3818.0	1960.9
13	90.33	62.65	3.09	2782.8	0.0	0.0	2527.5	1554.0
14	91.94	64.73	0.13	96.4	0.0	0.0	81.3	63.8
15	93.21	66.88	2.42	1197.7	0.0	0.0	741.7	952.7
16	94.87	69.96	0.89	111.3	0.0	0.0	-298.1	248.8

AG ɔ
Midvale UT s/n5206

WRL Embankment Stability – Seismic

2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.625



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```
********************************************************************************
*****                    GeoSlope                    *****
*****                  Version 5.00                  *****
*****                                                *****
*****      (c)1992 by GEOCOMP Corp, Concord, MA      *****
*****                Licensed to AGEC                *****
********************************************************************************
```

Problem Title : WRL Embankment Stability - Seismic
Description :
Remarks :

```
********************************************************************************
*****                   INPUT DATA                   *****
********************************************************************************
```

Profile Boundaries

Number of Boundaries : 6
Number of Top Boundaries : 5

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	50.00	50.00	50.00	2
2	50.00	50.00	60.00	55.00	2
3	60.00	55.00	92.00	71.00	1
4	92.00	71.00	117.00	71.00	1
5	117.00	71.00	150.00	60.00	1
6	60.00	55.00	150.00	55.00	2

Soil Parameters

Number of Soil Types : 2

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	300.0	32.0	0.00	0.0	1
2	105.0	105.0	40.0	31.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces : 1
Unit Weight of Water : 62.40 pcf
Piezometric Surface No. : 1
Number of Coordinate Points : 2

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	41.00
2	150.00	41.00

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Earthquake Loading
Horizontal Acceleration Coefficient : 0.093
Vertical Acceleration Coefficient : 0.000

****
*****   TRIAL SURFACE GENERATION   *****
****

Data for Generating Circular Surfaces
Number of Initiation Points : 50
Number of Surfaces From Each Point : 50
Left Initiation Point : 10.00 ft
Right Initiation Point : 55.00 ft
Left Termination Point : 90.00 ft
Right Termination Point : 140.00 ft
Minimum Elevation : 1.00 ft
Segment Length : 5.00 ft
Positive Angle Limit : 0.00 deg
Negative Angle Limit : 0.00 deg

****
*****   RESULTS   *****
****

Surface No. : 1
Factor of Safety : 1.625
Circle Center X : 56.90 ft
Circle Center Y : 89.77 ft
Circle Radius : 42.11 ft

Slice	X	Y	Width	Weight	Load	Water	Normal	Shear
	(ft)	(ft)	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	45.47	49.32	4.81	343.6	0.0	0.0	437.6	284.9
2	48.94	48.47	2.13	341.3	0.0	0.0	375.9	192.0
3	51.41	48.08	2.81	774.0	0.0	0.0	844.0	382.2
4	55.31	47.76	5.00	2565.7	0.0	0.0	2608.9	1087.8
5	58.90	47.76	2.19	1540.5	0.0	0.0	1496.3	607.4
6	61.40	47.96	2.79	2297.5	0.0	0.0	2232.5	894.5
7	65.24	48.57	4.90	4850.4	0.0	0.0	4581.0	1817.0
8	70.07	49.85	4.75	5436.8	0.0	0.0	5066.4	1996.5
9	74.71	51.69	4.53	5570.9	0.0	0.0	5194.2	2043.8
10	78.78	53.87	3.62	4510.2	0.0	0.0	4265.0	1682.1
11	80.91	55.19	0.62	768.4	0.0	0.0	662.1	390.3
12	83.17	56.95	3.90	4513.3	0.0	0.0	3855.4	2405.7
13	86.87	60.29	3.51	3425.6	0.0	0.0	2837.3	2014.2
14	90.16	64.05	3.06	2210.9	0.0	0.0	1616.5	1544.8
15	91.84	66.29	0.31	174.6	0.0	0.0	92.0	148.4
16	93.13	68.44	2.25	692.4	0.0	0.0	-3.1	808.9
17	94.41	70.66	0.30	12.3	0.0	0.0	-148.5	80.0

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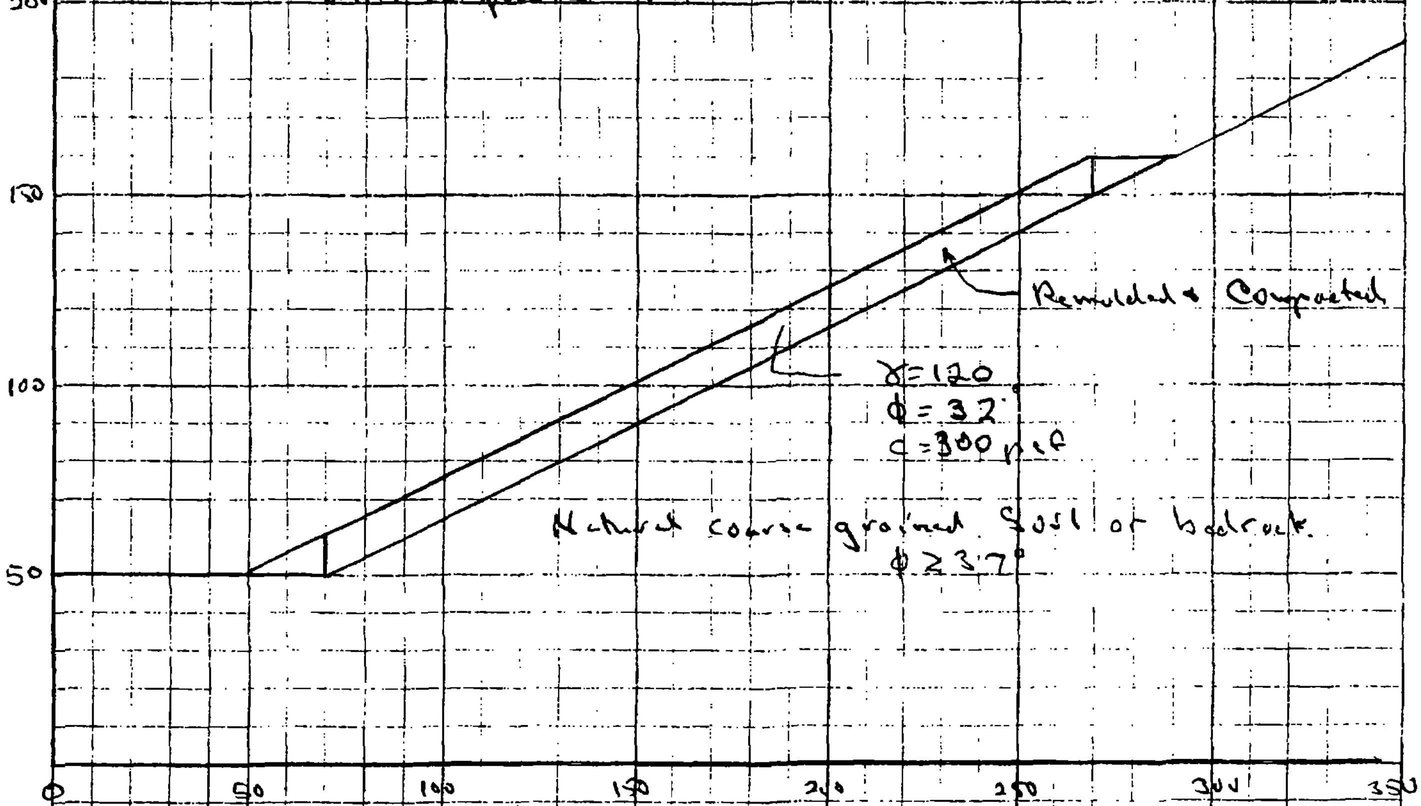
PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT Emb. Stability SHEET 8 OF 9

2:1 east facing slope

- excavation face will be covered with compacted fill.



Slope Stability

Slice	W	α	l	ϕ	c	$W\cos\alpha\tan\phi$	cl	$W\sin\alpha$
1	$(\frac{1}{2})(20)(10)(120) = 12{,}000$	0	20	32	300	7498	6000	0
2	$(200)(10)(120) = 240{,}000$	26.56	223	32	300	134142	66900	107,31[illegible]
3	$(\frac{1}{2})(20)(10)(120) = 12{,}000$	26.56	22.3	32	300	6707	6690	5,365
						148347	79590	112,6[illegible]

$$S.F. = \frac{148{,}347 + 79590}{112{,}677} = 2.02 \text{ ok}$$

$$\text{Seismic SF} = \frac{227{,}937}{112{,}677 + (0.0925)(264{,}000)} = 1.66 \text{ ok}$$

2:1 slope

w/ $\phi = 37^\circ$

Infinite slope - Static

$$S.F. = \frac{\tan 37^\circ}{\tan 26.5^\circ} = 1.51 \quad ok.$$

Infinite Slope - Seismic

$$= \frac{\cos 26.5^\circ}{\sin 26.5^\circ + K \cos 26.5^\circ} \tan 37^\circ$$

$K = 0.0925$

$S.F. = 1.27 \Rightarrow 1.3$ ok

Summary -

The 2:1 interior Slopes

Lowest S.F. is $\phi = 37^\circ$ $c = 0$

Static 1.51 ok

Seismic 1.3 ok

APPENDIX 4

Landfill Stability

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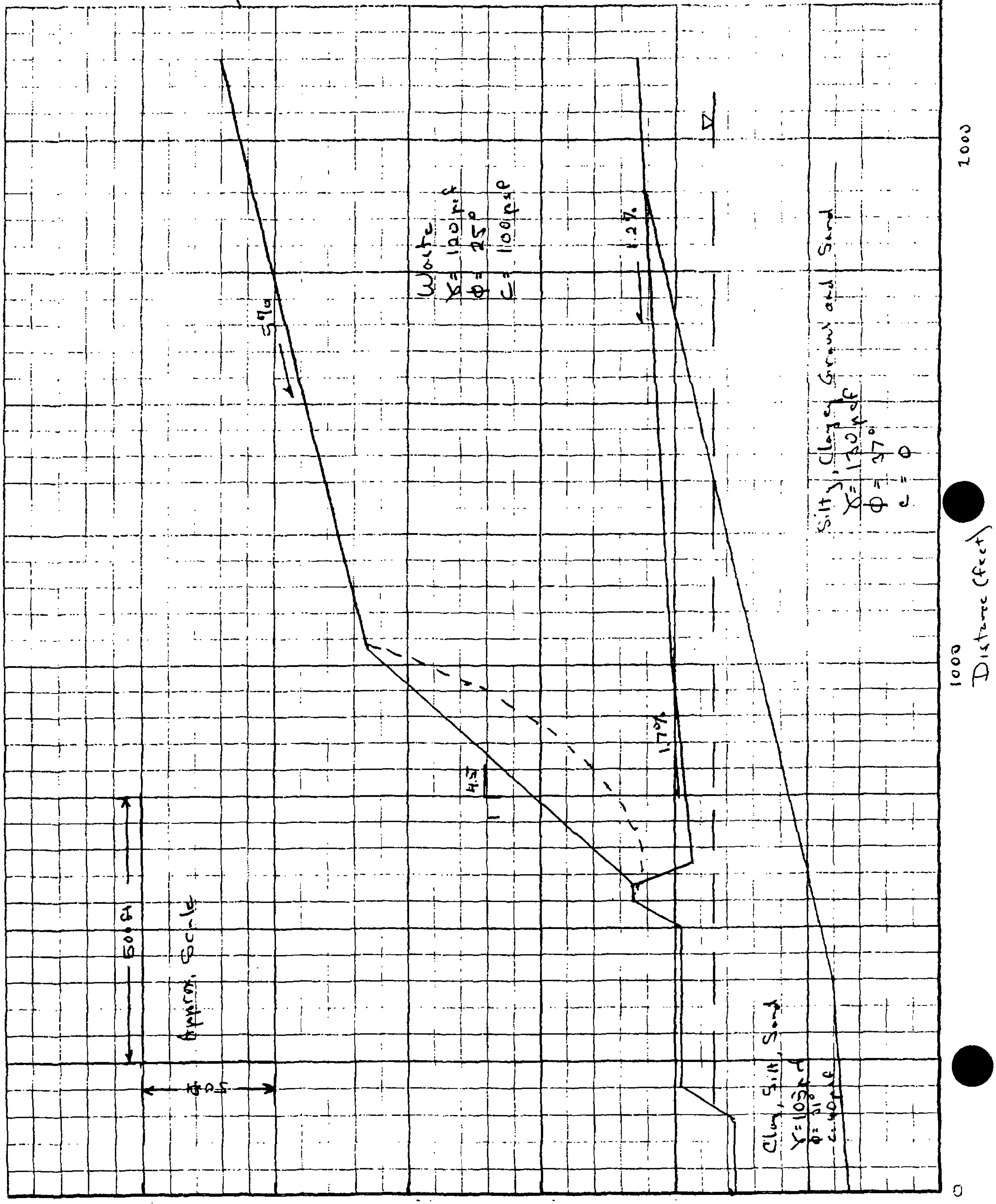
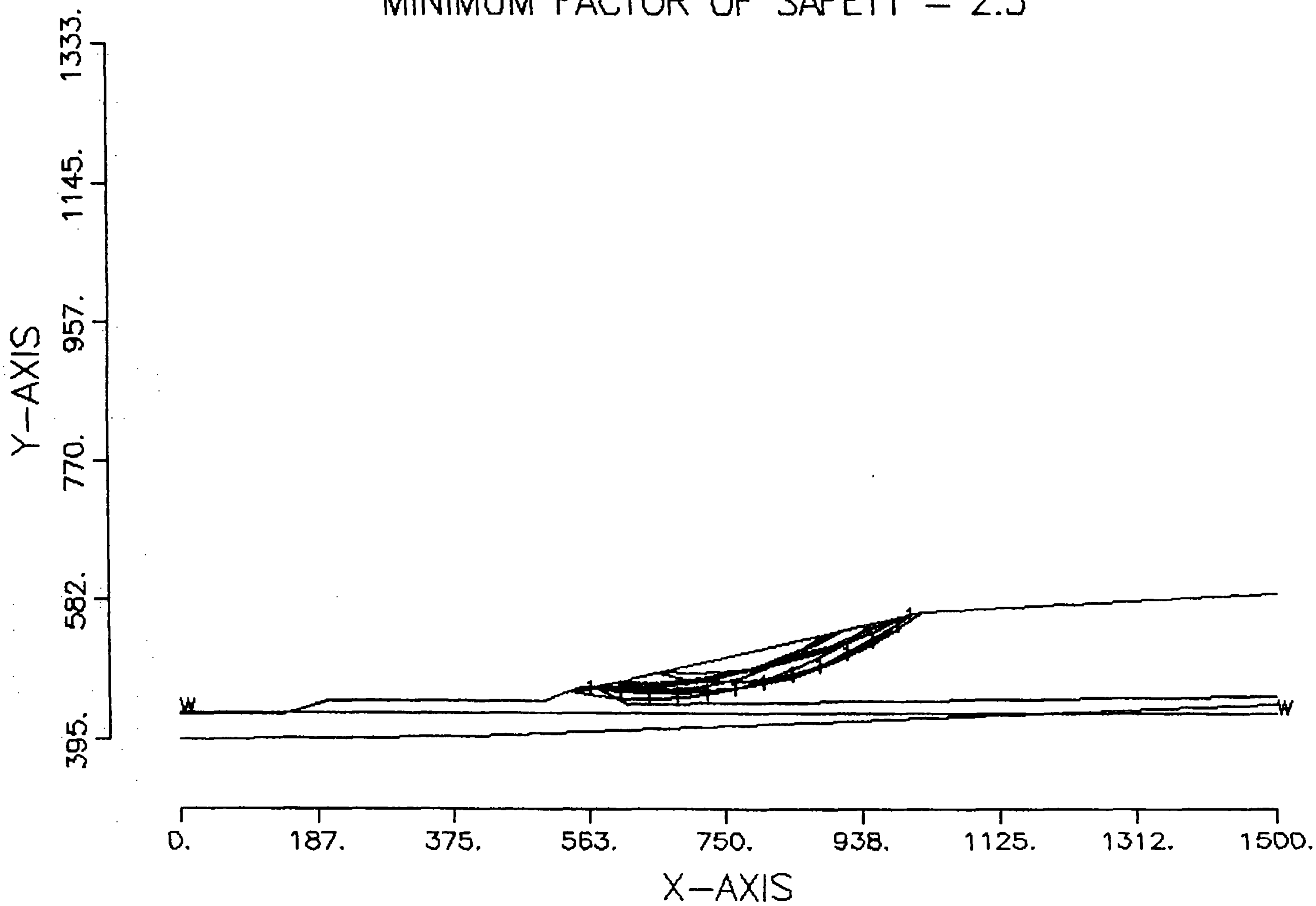
PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT Stability SHEET 1 OF 14



AGEC
Midvale UT s/n5206

Wasatch Regional Landfill waste slope st
atic
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.3



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*****                  Version 5.00                   *****
*****                                             *****
*****     (c)1992 by GEOCOMP Corp, Concord, MA              *****
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*****************************************************************************
```

Problem Title : Wasatch Regional Landfill waste slope static
Description :
Remarks :

```
*****************************************************************************
*****                    INPUT DATA                    *****
*****************************************************************************
```

Profile Boundaries

Number of Boundaries : 11

Number of Top Boundaries : 7

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	428.00	140.00	428.00	2
2	140.00	428.00	200.00	448.00	2
3	200.00	448.00	500.00	448.00	2
4	500.00	448.00	551.00	465.00	2
5	551.00	465.00	571.00	465.00	2
6	571.00	465.00	1021.00	565.00	1
7	1021.00	565.00	1500.00	590.00	1
8	571.00	465.00	613.00	444.00	2
9	613.00	444.00	1500.00	453.00	2
10	0.00	395.00	400.00	400.00	3
11	400.00	400.00	1500.00	443.00	3

Soil Parameters

Number of Soil Types : 3

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	100.0	25.0	0.00	0.0	1
2	105.0	105.0	40.0	31.0	0.00	0.0	1
3	130.0	130.0	0.0	37.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces : 1

Unit Weight of Water : 62.40 pcf

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Piezometric Surface No. : 1
Number of Coordinate Points : 2

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	430.00
2	1500.00	430.00

****
*****   TRIAL SURFACE GENERATION   *****
****

Data for Generating Circular Surfaces
Number of Initiation Points : 50
Number of Surfaces From Each Point : 50
Left Initiation Point : 450.00 ft
Right Initiation Point : 800.00 ft
Left Termination Point : 950.00 ft
Right Termination Point : 1400.00 ft
Minimum Elevation : 1.00 ft
Segment Length : 40.00 ft
Positive Angle Limit : 0.00 deg
Negative Angle Limit : 0.00 deg

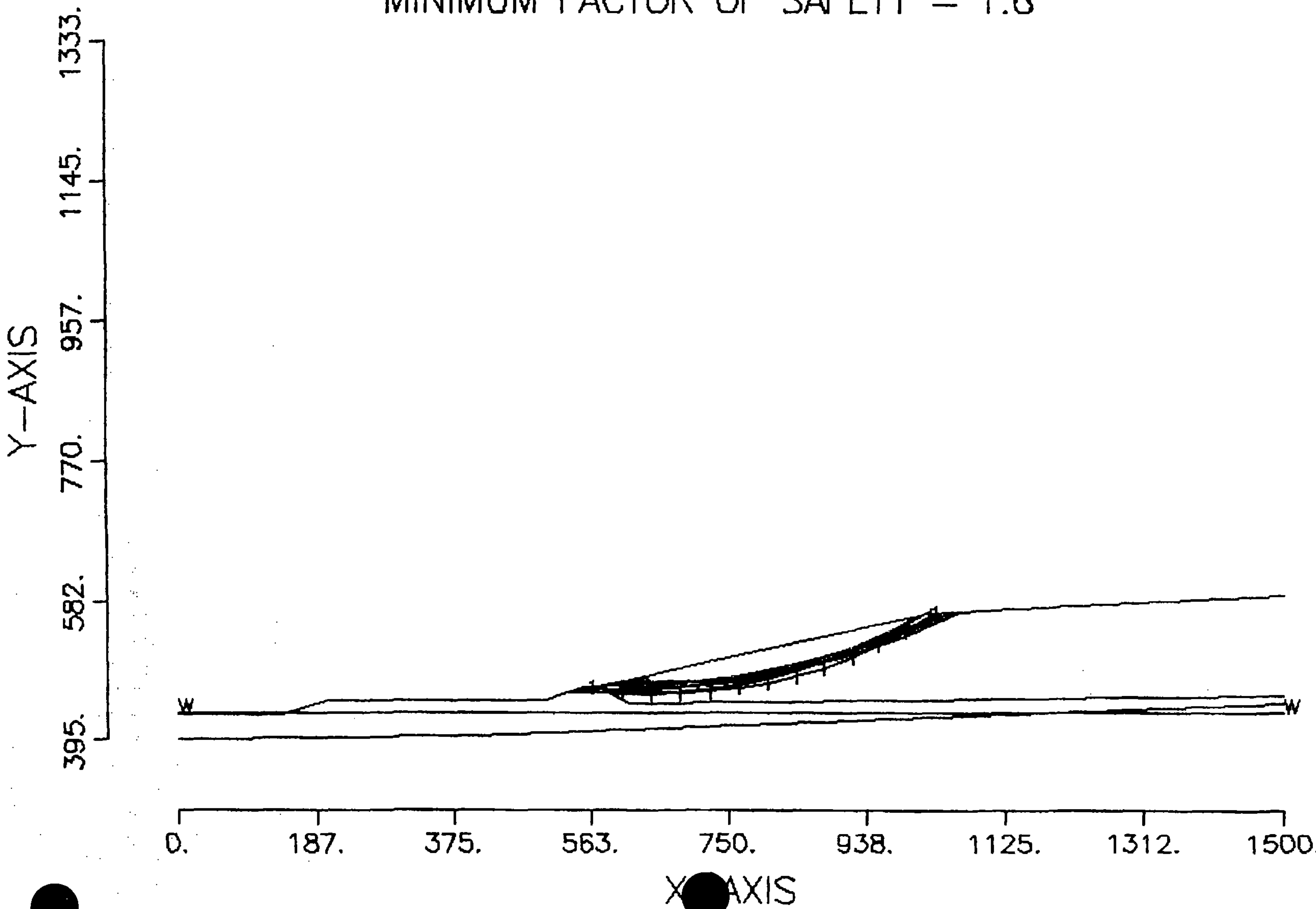
****
*****   RESULTS   *****
****

Surface No. : 1
Factor of Safety : 2.353
Circle Center X : 621.35 ft
Circle Center Y : 1362.72 ft
Circle Radius : 900.88 ft

Slice	X (ft)	Y (ft)	Width (ft)	Weight (lbs)	Load (lbs)	Water (lbs)	Normal (lbs)	Shear
1	550.50	464.64	1.00	20.5	0.0	0.0	21.8	22.6
2	561.00	464.04	20.00	2019.7	0.0	0.0	2072.7	869.6
3	572.73	463.37	3.46	798.1	0.0	0.0	814.6	266.9
4	582.20	462.83	15.47	8656.0	0.0	0.0	8807.4	2403.6
5	609.93	462.13	40.00	55295.6	0.0	0.0	55461.0	12688.4
6	649.92	462.51	39.98	96078.1	0.0	0.0	95472.2	20616.1
7	689.85	464.67	39.88	128002.4	0.0	0.0	126335.3	26731.2
8	729.65	468.59	39.71	150877.1	0.0	0.0	148217.0	31066.7
9	769.23	474.28	39.46	164631.5	0.0	0.0	161294.2	33657.8
10	808.53	481.72	39.13	169316.0	0.0	0.0	165756.5	34541.9
11	847.45	490.90	38.72	165101.6	0.0	0.0	161808.1	33759.6
12	885.93	501.79	38.24	152277.6	0.0	0.0	149670.4	31354.7
13	923.88	514.39	37.68	131249.5	0.0	0.0	129583.3	27374.7
14	961.24	528.65	37.04	102534.6	0.0	0.0	101808.5	21871.5
15	997.93	544.56	36.34	66757.6	0.0	0.0	66630.7	14901.6
16	1018.55	554.19	4.90	6039.2	0.0	0.0	6054.8	1434.0
17	1031.31	560.76	20.62	11815.3	0.0	0.0	11599.4	3284.0

AGE
Midvale UT s/n5206

Wastach Regional Landfill waste slope dy
namic
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.6



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```

Problem Title : Wastach Regional Landfill waste slope dynamic
Description :
Remarks :

```
*****************************************************************************
*****                INPUT DATA               *****
*****************************************************************************
```

Profile Boundaries

Number of Boundaries : 11
Number of Top Boundaries : 7

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	428.00	140.00	428.00	2
2	140.00	428.00	200.00	448.00	2
3	200.00	448.00	500.00	448.00	2
4	500.00	448.00	551.00	465.00	2
5	551.00	465.00	571.00	465.00	2
6	571.00	465.00	1021.00	565.00	1
7	1021.00	565.00	1500.00	590.00	1
8	571.00	465.00	613.00	444.00	2
9	613.00	444.00	1500.00	453.00	2
10	0.00	395.00	400.00	400.00	3
11	400.00	400.00	1500.00	443.00	3

Soil Parameters

Number of Soil Types : 3

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	100.0	25.0	0.00	0.0	1
2	105.0	105.0	40.0	31.0	0.00	0.0	1
3	130.0	130.0	0.0	37.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces : 1
Unit Weight of Water : 62.40 pcf

Piezometric Surface No. : 1
Number of Coordinate Points : 2

1040644

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Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	430.00
2	1500.00	430.00

Earthquake Loading

Horizontal Acceleration Coefficient : 0.093

Vertical Acceleration Coefficient : 0.000

****

***** TRIAL SURFACE GENERATION *****

****

Data for Generating Circular Surfaces

Number of Initiation Points : 50

Number of Surfaces From Each Point : 50

Left Initiation Point : 450.00 ft

Right Initiation Point : 800.00 ft

Left Termination Point : 950.00 ft

Right Termination Point : 1400.00 ft

Minimum Elevation : 1.00 ft

Segment Length : 40.00 ft

Positive Angle Limit : 0.00 deg

Negative Angle Limit : 0.00 deg

****

***** RESULTS *****

****

Surface No. : 1

Factor of Safety : 1.628

Circle Center X : 621.35 ft

Circle Center Y : 1362.72 ft

Circle Radius : 900.88 ft

Slice	X (ft)	Y (ft)	Width (ft)	Weight (lbs)	Load (lbs)	Water (lbs)	Normal (lbs)	Shear
1	550.50	464.64	1.00	20.5	0.0	0.0	22.4	32.9
2	561.00	464.04	20.00	2019.7	0.0	0.0	2095.3	1265.2
3	572.73	463.37	3.46	798.1	0.0	0.0	821.6	388.3
4	582.20	462.83	15.47	8656.0	0.0	0.0	8869.6	3491.7
5	609.93	462.13	40.00	55295.6	0.0	0.0	55532.9	18358.7
6	649.92	462.51	39.98	96078.1	0.0	0.0	95183.5	29713.0
7	689.85	464.67	39.88	128002.4	0.0	0.0	125446.8	38379.2
8	729.65	468.59	39.71	150877.1	0.0	0.0	146597.7	44435.9
9	769.23	474.28	39.46	164631.5	0.0	0.0	158913.2	47962.6
10	808.53	481.72	39.13	169316.0	0.0	0.0	162676.3	49040.2
11	847.45	490.90	38.72	165101.6	0.0	0.0	158179.3	47752.4
12	885.93	501.79	38.24	152277.6	0.0	0.0	145727.0	44186.6
13	923.88	514.39	37.68	131249.5	0.0	0.0	125639.3	38434.3
14	961.24	528.65	37.04	102534.6	0.0	0.0	98254.6	30592.5
15	997.93	544.56	36.34	66757.6	0.0	0.0	63932.4	20764.0
16	1018.55	554.19	4.90	6039.2	0.0	0.0	5768.1	1990.4
17	1031.31	560.76	20.62	11815.3	0.0	0.0	10942.8	4558.2

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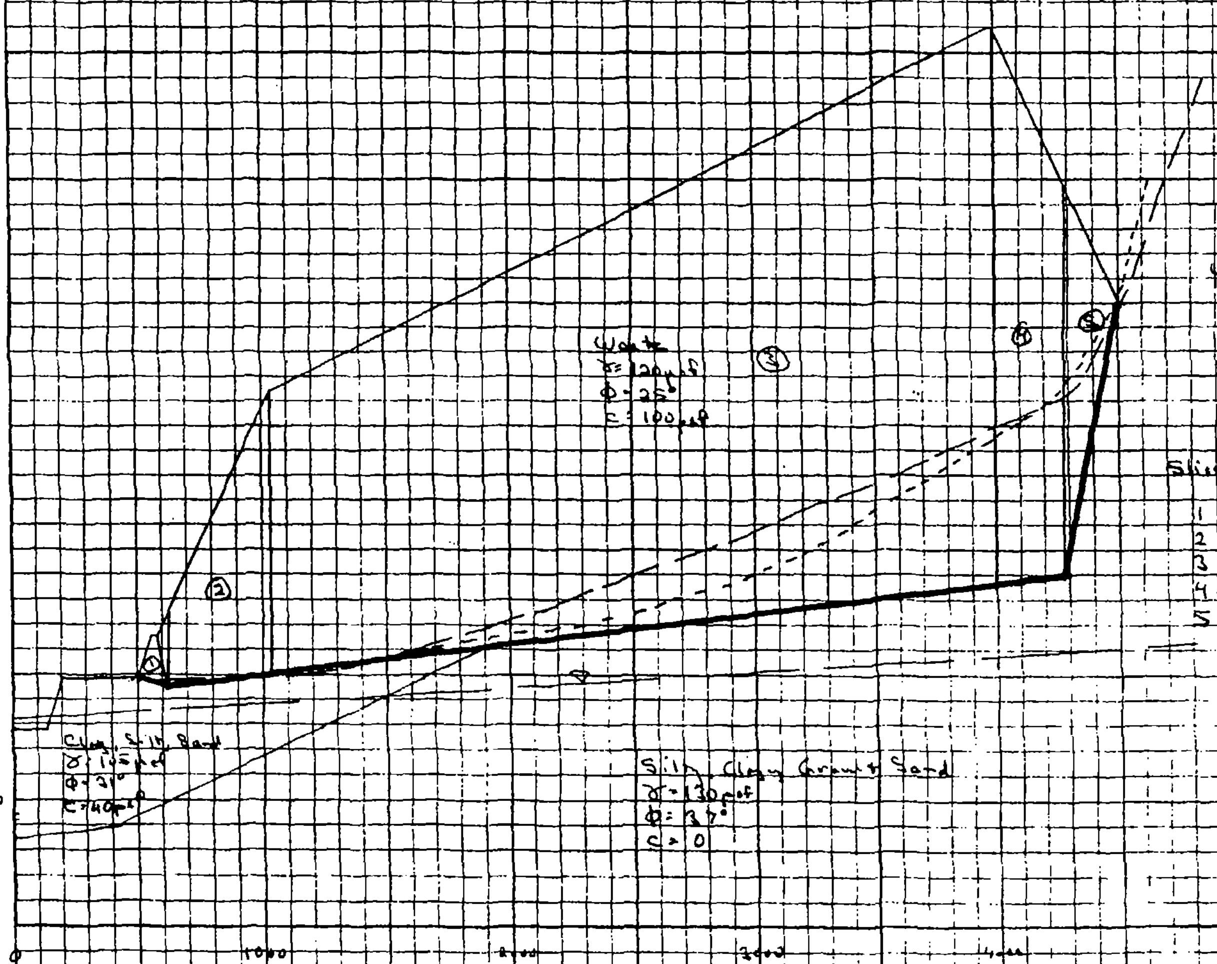

Sliding Wedge Stability

Weight

1 - (130)(200)(105) = 2,730,000
2 - (410)(20+112)(1/2)(130) = 3,517,800
3 - (2950)(113+224)(1/2)(120) = 59,649,000
4 - (200)(224+157)(1/2)(120) = 6,400,800
5 - (220)(157)(1/2)(120) = 2,072,400

Slice	W	l	α	c	φ	W cos α tan φ	cl	W sin α
1	2730,000	130	-1.94°	40	31	1,639,400	5200	-92,418
2	3517,800	410	0.974°	0	8	494,323	-	59,798
3	59,649,000	2950	0.688°	0	8	8,383,515	-	716,240
4	6,400,800	200	0.688°	0	8	899,508	-	76,858
5	2072,400	237	27.6°	95	23.9	813,855	22,515	960,135
						12,229,601	27,715	1,720,613

$$S.F. = \frac{12,229,601 + 27715}{1720613} = 7.1 \quad ok$$

Seismic - Add Eq to driving (W)(Eq)

= (0.2107)(0.44) = 0.0925

SF = 12,257,316 / [1720613 + (0.0925)(74,370,000)]

1.43 ok

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SUBJECT Geosynthetic Stability SHEET 9 OF 14

Basis of Analysis

- Infinite Slope (if ϕ only)

- Seismic $a = 0.21g$ (2% in 50 yrs.)
  reduced $(0.44)(0.21) = 0.0925$

- Safety Factor

$$\text{Static} \quad S.F. = \frac{\tan\phi}{\tan\alpha}$$

$$\text{Seismic} \quad S.F. = \frac{\cos\alpha}{\sin\alpha + k\cos\alpha}\tan\phi$$

- If ϕ + c material.

$$\text{Static} \quad S.F. = \frac{W\cos\alpha\tan\phi + cl}{W\sin\alpha}$$

$$\text{Seismic} \quad S.F. = \frac{W\cos\alpha\tan\phi + cl}{W\sin\alpha + kW}$$

- Calculations

Location	Slope	Strength: Friction	Strength: Cohesion		S.F. Static	S.F. Seismic
Floor	1.7%	8°	0		8.3	1.3
Interior Side	2:1	18	50	See soil cover section		
		26	30			
		23.9	95			
Exterior Top	5%	~~21.5°~~	~~84~~	*	~~3.8~~	~~2.8~~
		18	50		10.7	3.7
Exterior Side	4:1	~~23.9°~~	~~95~~	*	~~1.8~~	~~1.3~~
		18	50		~~(w/o cohesive)~~	
					2.2	1.6

* See next page

AGEC

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 6/15/05 BY [illegible]

SUBJECT Geosynthetic Stability SHEET 9a OF 14

- Plan now includes the possibility of a GCL in the closure cap.
- The weakest condition is within the GCL

Static $S.F. = \dfrac{W \cos\alpha \tan\phi + cl}{W \sin\alpha}$

Top $\alpha = 2.86°$
$W = (120\text{ pcf})(2\text{ ft})$
$= 240\text{ psf/ft}$

Slope $\alpha = 14.04°$
$W = 240\text{ psf/ft}$

Top

$S.F. = \dfrac{(240)(\cos 2.86)(\tan 18°) + (50\text{ psf})(1\text{ ft})}{(240)\sin 2.86}$

$= 10.7$ ok

Slope

$S.F. = \dfrac{(240)(\cos 14.04)(\tan 18°) + (50)(1)}{(240)\sin 14.04}$

$= 2.16$ ok

Seismic

Top

$S.F. = \dfrac{(240)\cos 2.86 \tan 18 + (50)(1)}{(240)\sin 2.86 + (0.0925)(240)}$

$= 3.7$ ok

Side Slope

$S.F. = \dfrac{(240)(\cos 14.04)(\tan 18) + (50)(1)}{(240)\sin 14.04 + (0.0925)(240)}$

$= 1.56$ ok

1040644 10/14

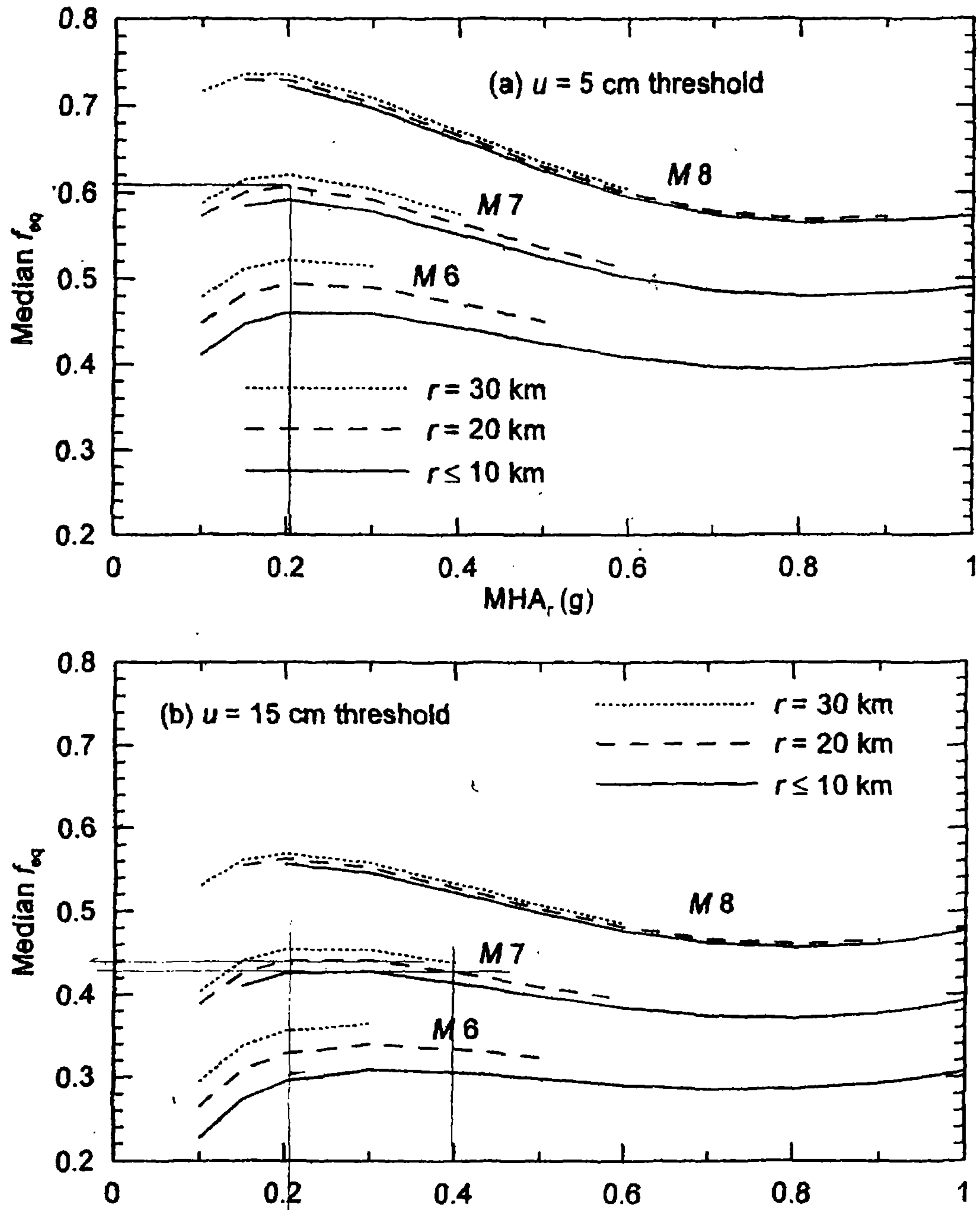

Figure 11.1. Required Values of f_{eq} as Function of MHA$_r$ and Seismological Condition for Threshold Displacements of (a) 5 cm and (b) 15 cm

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SUBJECT Stability SHEET 11 OF 14

Floor Stability

$$S.F. = \frac{\tan 8^\circ}{\tan 0.974} = 8.3 \text{ ok}$$

$$S.F._{eq} = \frac{(\cos 0.974)(\tan 8^\circ)}{\cancel{(\sin 0.974) + (0.0925 \cos 0.974)}} = 1.28 > 1.3 \text{ ok}$$

Interior Side

Assume 47' Soil Cover (21') $w = (2)(47)(120 pcf)$
$= 11,280$ plf

$$\text{Static } SF = \frac{(11280)\cos 26.5 \tan\phi + c(47)}{(11280)\sin 26.5}$$

$$= \frac{10,095 \tan\phi + 47c}{5033}$$

ϕ	c	SF	
18°	50 psf	1.12	(hydrated bentonite)
26°	30 psf	1.26	(GCL/Soil)
23.9°	95 psf	1.78	(Soil cover / HDPE)

Need to consider flattening cover slope and or include the passive (toe) resistance

See Appendix 5 for soil cover stability

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SUBJECT Stability SHEET 12 OF 14

Closure Top.

5% $\phi = 21.5$ $c = 84$ psf

using friction only

Static S.F. $= \dfrac{\tan 21.5}{\tan 2.86} = 7.9$ ok

Seismic S.F. $= \dfrac{\cos 2.86 \tan 21.5}{\sin 2.86 + (0.0925)\cos 2.86}$

$= 2.76$ ok

with seepage down slope (full)

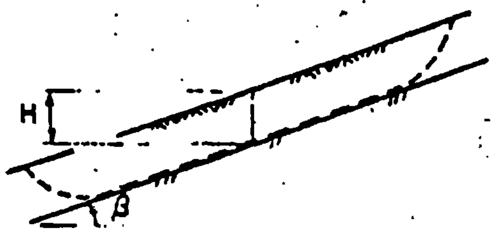
$r_u = \dfrac{\gamma_w}{\gamma} \cos^2 \alpha$

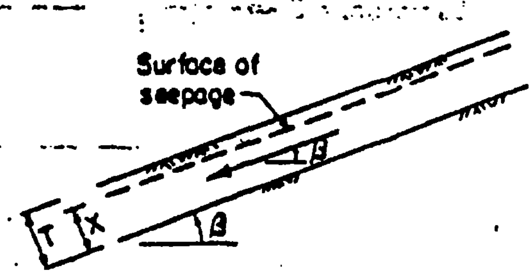
$= \dfrac{62.4}{120} \cos^2 2.86 = 0.52$

$A = 0.48$

$SF = (0.48) \dfrac{\tan 21.5}{\tan 2.86} = 3.78$ ok

1040644





γ = total unit weight of soil

γ_w = unit weight of water

C' = cohesion intercept } Effective Stress

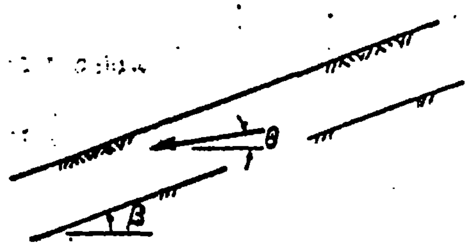
ϕ' = friction angle

r_u = pore pressure ratio $= \frac{u}{\gamma H}$

u = pore pressure at depth H

Seepage parallel to slope

$$r_u = \frac{X}{T}\,\frac{\gamma_w}{\gamma}\cos^2\beta$$

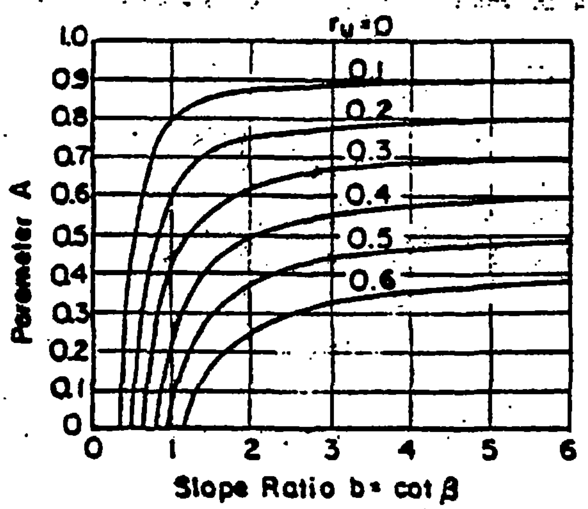


Seepage emerging from slope

$$r_u = \frac{\gamma_w}{\gamma}\,\frac{1}{1+\tan\beta\tan\theta}$$

Steps:

1. Determine r_u from measured pore pressures or formulas at right
2. Determine A and B from charts below
3. Calculate $F = A\,\frac{\tan\phi'}{\tan\beta} + B\,\frac{C'}{\gamma H}$



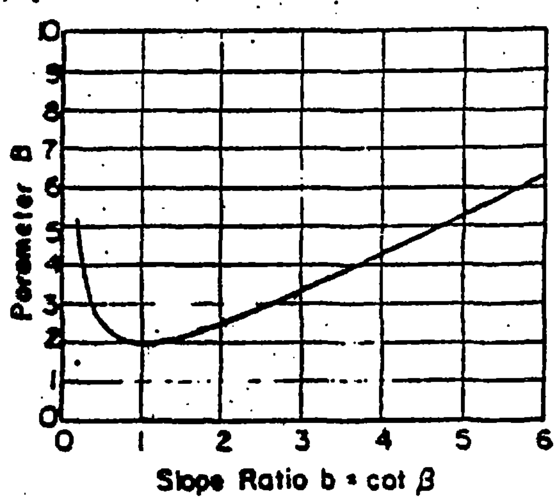


Fig. 10 STABILITY CHARTS FOR INFINITE SLOPES.

Fig. 11 SLOPE STABILITY CHARTS FOR [illegible] AND STRENGTH [illegible] WITH DEPTH. (after Hunter and [illegible])

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PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY 91

SUBJECT Stability SHEET 14 OF 14

4:1 Side Slopes

$\phi = 23.9°$ $c = 95$ psf

$$\text{Static S.F.} = \frac{\tan 23.9°}{\tan 14.0°} = \underline{\underline{1.8}} \text{ ok}$$

$$\text{Seismic S.F.} = \frac{\cos 14.0 \; \tan 23.9°}{\sin 14.0 + (0.0915)\cos 14.0} = \underline{\underline{1.3}} \text{ ok}$$

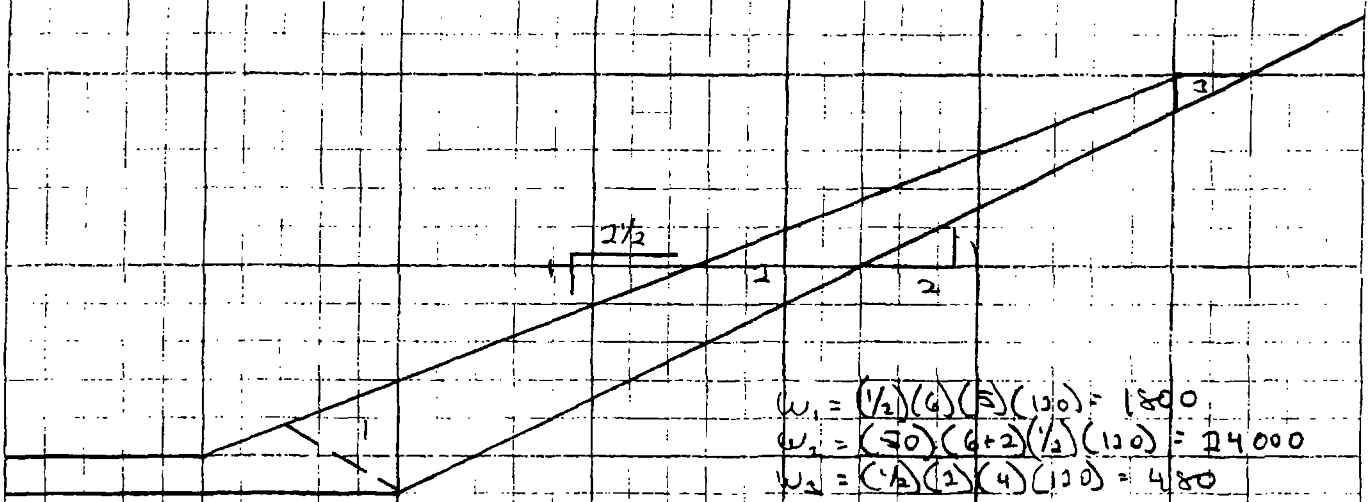
APPENDIX 5

Soil Cover Stability

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY

SUBJECT Cover Stability (Protective) SHEET 1 OF 6



$W_1 = (\frac{1}{2})(6)(5)(120) = 1800$

$W_2 = (50)(6+2)(\frac{1}{2})(120) = 24000$

$W_3 = (\frac{1}{2})(2)(4)(120) = 480$

Slice	W	α	l	φ	c	W cos α tan φ	c l	W sin α
1	1800	-30.9	7	25	100	720	700	-924
2	24000	26.5	44.7	18	50	6979	2235	10,709
3	480	26.5	4.5	18	50	140	225	214
						7839	3160	9999

$S.F. = \frac{7839 + 3160}{9999} = 1.10$

(harsh leachate)

Slice								
1	1800	-30.9	7	25	100	720	700	-924
2	24000	26.5	44.7	26	30	10,476	1341	10,709
3	480	26.5	4.5	26	30	210	135	214
						11,406	2176	9999

$S.F. = \frac{11,406 + 2176}{9990} = 1.36$

(GCL/Soil)

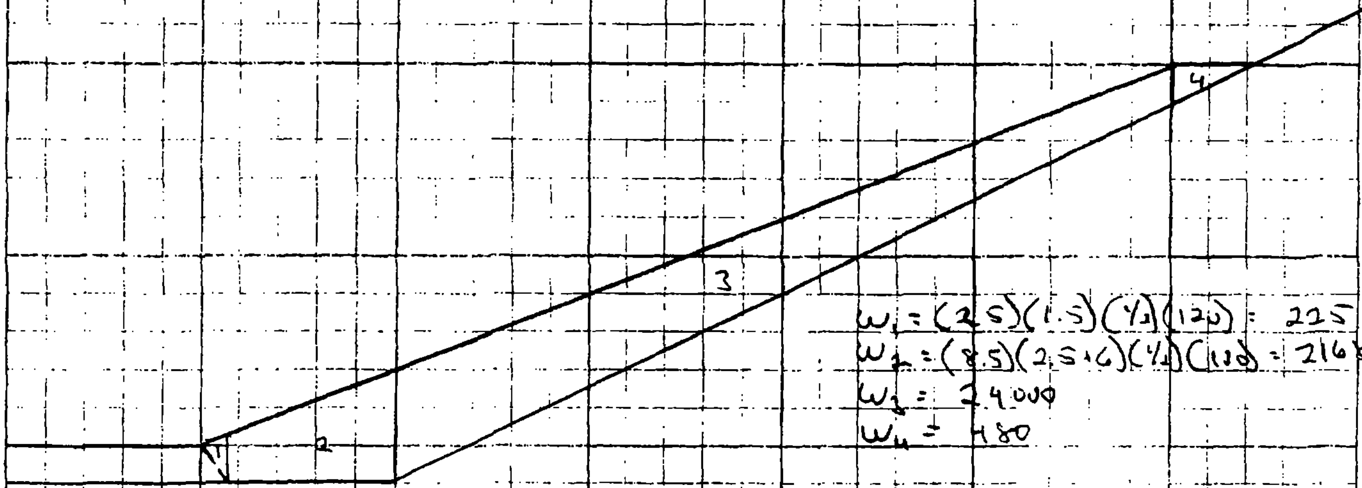
add 50% tension of fabric in GCL 360 lb/ft

S.F. = 1.4

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY SD

SUBJECT PC Stability SHEET 2 OF 6



$W_1 = (2.5)(1.5)(1/2)(120) = 225$

$W_2 = (8.5)(2.5+6)(1/2)(120) = 2168$

$W_3 = 24000$

$W_4 = 480$

Slice	W	α	l	φ	c	W cos α tan φ	c l	W sin α
1	225	-57.5	2	25	100	56	200	-190
2	2168	0	8.5	8	0	305	0	0
3	24000	26.5	44.7	26	30	10475	1341	10,709
4	480	26.5	4.5	26	30	210	135	214
						11,046	1676	10,733

$$S.F. = \frac{11{,}047 + 1676}{10{,}733} = 1.2$$

+ tension - 360 lb/ft

S.F. = 1.2

Conclusion - The interface between synthetic materials and synthetic / soil should be verified.

- The S.F. on the order of 1.1 to 1.4 (as calculated) will be higher when actual laboratory tests indicate higher shear strengths. In other words - the strengths used in this analysis are low!

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT PC Stability SHEET 3 OF 6

Seismic

$$S.F. = \frac{11047 + 1676 + 360}{10{,}733 + (0.0925)(26{,}873)} = 0.99$$

$\underline{1.0}$

What tension is needed for S.F. = 1.5

$$1.5 = \frac{11{,}047 + 1676 + T}{10{,}733}$$

$$T = 3376$$

What friction below GCL (cohesion too)

$$1.5 = \frac{361 + 210 + 1676 + \frac{10685}{\tan 26}(\tan\phi) + 200 + \frac{1476}{30}(c)}{10{,}733}$$

$$13652 = 21907 \tan\phi + 49.2\, c$$

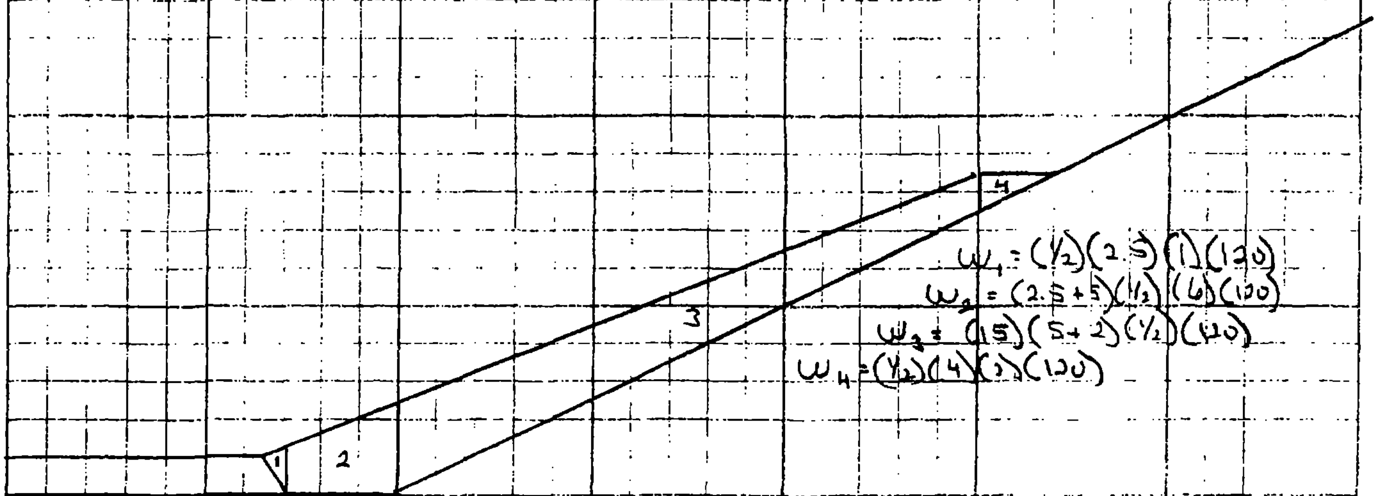
ϕ	c
29.0	30
26.0	60

(Much of the literature indicates that these values are realistic).

PROJECT NO. 1040644 TITLE WAL DATE 12/17/04 BY [illegible]
SUBJECT PC Stability SHEET 4 OF 6

How high can we go and maintain S.F. = 1.5

Try 15' high



$W_1 = (1/2)(2.5)(1)(120)$
$W_2 = (2.5+5)(1/2)(6)(120)$
$W_3 = (15)(5+2)(1/2)(120)$
$W_4 = (1/2)(4)(2)(120)$

Slice	W	α	l	φ	c	W cos α tan φ	c l	W sin α
1	150	-57.5	2	25	100	38	200	-127
2	2700	0	6	8	0	379	0	0
3	13,889	26.5	33.5	26	30	6062	1005	6197
4	480	26.5	4	26	30	210	120	214
						6689	1325	6284

$$S.F. = \frac{6689 + 1325}{6289} = 1.28$$

add tension 360 lb/ft

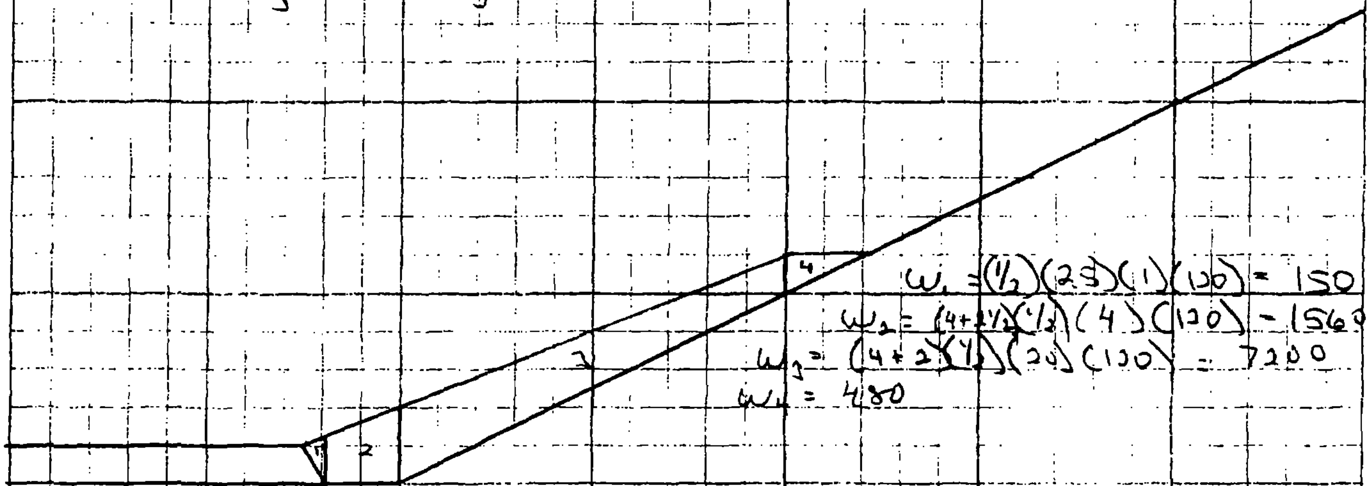
S.F. = 1.33

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT PC Stability SHEET 5 OF 6

Try 10' high



$W_1 = (1/2)(2.5)(1)(120) = 150$

$W_2 = (4+2\tfrac{1}{2})(1/2)(4)(120) = 1560$

$W_3 = (4+2)(1/2)(20)(120) = 7200$

$W_4 = 480$

Slice	W	α	l	φ	c	W cos α tan φ	c l	W sin α
1	150	-57.5	2	25	100	38	200	-127
2	1560	0	4	8	0	219	0	0
3	7200	26.5	22	26	30	3143	660	3213
4	480	26.5	4.5	26	30	210	120	214
						3610	980	3300

$$S.F. = \frac{3610 + 980}{3300} = 1.39$$

add tension

$$S.F. = \frac{4590 + 360}{3300} = \underline{1.5} \quad ok$$

Check Seismic

$$S.F. = \frac{4590 + 360}{3300 + (0.0925)(9390)} = 1.19$$

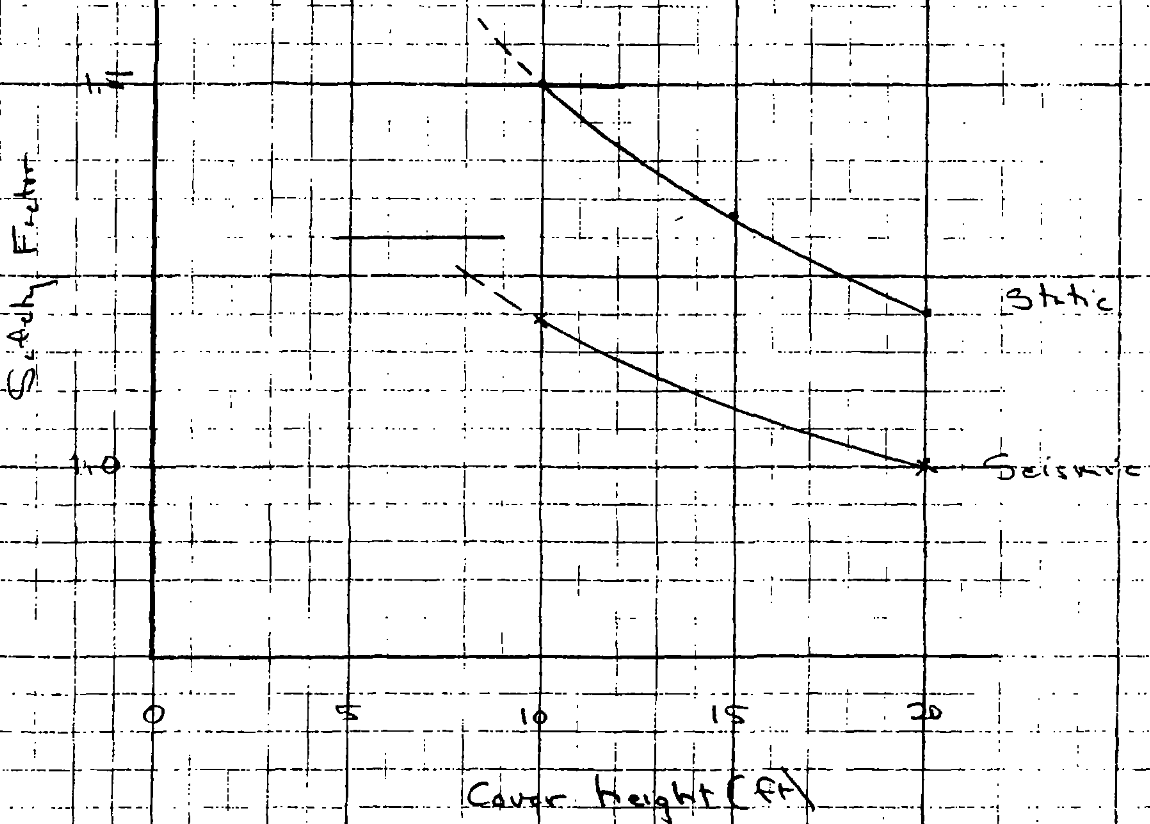
would be 1.25 w/ 620 lb/ft tension

86% of yield - ok

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY [illegible]

SUBJECT Cover Stability SHEET 6 OF 6



With assumed strengths

Static => 10' high

Seismic => 7' high

If we use more tension (84%) for seismic. 10' is ok.

APPENDIX 6

Settlement

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 12/17/04 BY

SUBJECT Settlement SHEET 1 OF 3

Settlement

Toe embankment - (17)(105) = 1785 psf

0 - 18 CL-ML
18 - 40 CL-ML (water)
40 - GM

(19.37)(2/3) + (6.4)(0.7) = 13.2" .77

Inflection Point (115)(120 psf) = 13,800 psf

0 - 18 CL-ML (6.9)(0.35) = 2.4 .23
18 - 25 CL-ML (water)
25 - GM

(27.1)(0.66) + (23)(0.7) = 26"

150' Waste = 18,000 psf

0 - 25 GM (9)(0.35) = 3.2"
25 - GM (wet)

(4.567)(0.7) = 3.2" 0.02

200' Waste = 24,000 psf

0 - 40' GM (12)(0.35) = 4.2
40 - GM (wet)

(5.675)(0.7) = 4" .02

240' Waste = 28,800 psf

0 - 50' GM 0.0007 (14.4)(0.35) = 5"
50 - GM (wet)

(7.364)(.7) = 5.15"

1"/50' of waste
12"/50' of waste

1040644 2/3

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):****** ft Load:28800 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	LAYER DEPTH (FT)	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	SETTLEMENT RECOMP (IN)
1	gm	****	****	130.0	.0010	.0010	7.364	.000

TOTAL SETTLEMENT= 7.364 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):****** ft Load:28800 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	LAYER DEPTH (FT)	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	SETTLEMENT RECOMP (IN)
1	gm	****	****	130.0	.0010	.0010	7.364	.000

TOTAL SETTLEMENT= 7.364 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):4000.0 ft Load:24000 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	LAYER DEPTH (FT)	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	SETTLEMENT RECOMP (IN)
1	gm	****	****	130.0	.0010	.0010	5.675	.000

TOTAL SETTLEMENT= 5.675 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):4000.0 ft Load:18000 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

1040644

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	DEPTH	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	RECOMP (IN)
1	gm	****	****	130.0	.0010	.0010	4.567	.000

TOTAL SETTLEMENT= 4.567 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):4000.0 ft Load:13800 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	DEPTH	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	RECOMP (IN)
1	gm	****	****	130.0	.0010	.0010	3.721	.000

TOTAL SETTLEMENT= 3.721 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):4000.0 ft Load:13800 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	DEPTH	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	RECOMP (IN)
1	CL/ML	25	25	105.0	.1040	.1400	37.117	.000
2	gm	974	999	130.0	.0010	.0010	2.315	.000

TOTAL SETTLEMENT= 39.432 inches

JOB NUMBER:

Constant Maximum Past Pressure: 0 psf
Length(X): 4000.0 ft Width(Y):4000.0 ft Load: 1800 psf X-Coord = .0 ft
Water Depth: 22 ft Load Depth: 0 ft Fill: 0 ft Y-Coord = .0 ft

SOIL LAYER	SOIL TYPE	LAYER THICK (FT)	DEPTH	SOIL DENSITY (PSF)	COMP RATIO	RECOMP RATIO	SETTLEMENT VIRGIN (IN)	RECOMP (IN)
1	CL/ML	40	40	105.0	.1040	.1400	19.370	.000
2	gm	959	999	130.0	.0010	.0010	.393	.000

TOTAL SETTLEMENT= 19.763 inches

APPENDIX 7

Liquefaction

LIQUEFACTION POTENTIAL AND LIQUEFACTION INDUCED SETTLEMENT

Project No.	1040629			Salt Lake Liq. Hazard Rating	
Project Name	Wasatch Regional Landfill	Earthquake Magnitude	7.2	Liq. Potential	PGA
Date	17-Dec-04	Magnitude Scaling Factor	1.11	Very Low	>0.33g
Time	2:16 PM	Hammer Energy Ratio	1.5	Low	0.23g-0.33g
Site PGA for 10% in 50 yrs	0.11 g	Soil Total Unit Wt, pcf	120	Moderate	0.13g-0.23g
Site PGA for 2% in 50 yrs	0.22 g	Hole Diameter, in	3.75 95.25 1	High	<0.13g

Site PGA based on Frankel, A.C., Mueller, T., Barnhard, D., Perkins, E.V., Leyendecker, N., Dickman, S., Hanson, S. and Hopper, M., 1996, National Seismic Hazard Maps, U.S. Geological Survey Open-File Report 96-532

Liquefaction potential based on Youd, T.L. and I.M. Idriss, 1997, Proceedings of the NCEER workshop on liquefaction resistance of soils, Technical Report NCEER-97-0022

Liquefaction induced settlement based on Tokimatsu, A.M. and H.B. Seed, 1987, Evaluation of settlements in sands due to earthquake shaking, Journal of Geotechnical Engineering, Vol 113, No. 8, pp 861-878

									Corrections to SPT						LIQUEFACTION POTENTIAL							LIQUEFACTION INDUCED SETTLEMENT					
Boring	Sample Depth, ft	N	Sample Type, 1=Cal 2=SPT	% Fines	Soil Type	Water Depth, ft	Total Stress, tsf	Effective Stress, tsf	Overburden Press., C_N	Energy Ratio, C_E	Bore Dia., C_B	Rod Length, C_R	Sample Type, C_S	Total SPT Corr.	$(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{7.5}$	CRR_M	r_d	Acc. To Cause Liq., a_L	Liq. Potential	$(N_1)_{60cs}$	10% in 50 Yr CSR	Layer Thick., ft	Vol. Strain, %	Sett., in	Cum. Sett., in
B-1	2	69	1	0	GM	136	0.120	0.120	2.00	1.5	1	0.75	0.82	1.85	108.9	108.9	0.457	0.507	1.00	0.782	Non	108.9	0.071			0.00	0.00
B-1	4	37	1	0	GM	136	0.240	0.240	2.00	1.5	1	0.75	0.82	1.85	68.3	68.3	0.457	0.507	0.99	0.786	Non	68.3	0.071			0.00	0.00
B-1	9	23	1	0	GM	136	0.540	0.540	1.36	1.5	1	0.75	0.82	1.26	28.9	28.9	0.370	0.411	0.98	0.644	Non	28.9	0.070			0.00	0.00
B-1	14	100	1	0	GM	136	0.840	0.840	1.09	1.5	1	0.80	0.82	1.08	107.5	107.5	0.457	0.507	0.97	0.804	Non	107.5	0.069			0.00	0.00
B-1	19	36	1	0	GM	136	1.140	1.140	0.94	1.5	1	0.86	0.82	1.01	36.3	36.3	0.457	0.507	0.96	0.813	Non	36.3	0.069			0.00	0.00
B-1	24	100	1	0	GM	136	1.440	1.440	0.83	1.5	1	0.93	0.82	0.95	95.0	95.0	0.457	0.507	0.95	0.825	Non	95.0	0.068			0.00	0.00
B-1	29	69	1	0	GM	136	1.740	1.740	0.76	1.5	1	0.96	0.82	0.89	61.3	61.3	0.457	0.507	0.93	0.843	Non	61.3	0.066			0.00	0.00
B-1	34	100	1	0	GM	136	2.040	2.040	0.70	1.5	1	0.96	0.82	0.83	82.7	82.7	0.457	0.507	0.90	0.869	Non	82.7	0.064			0.00	0.00
B-1	39	100	1	0	SM	136	2.340	2.340	0.65	1.5	1	0.97	0.82	0.78	77.7	77.7	0.457	0.507	0.86	0.908	Non	77.7	0.061			0.00	0.00
B-1	44	22	1	0	CL	136	2.640	2.640	0.62	1.5	1	0.97	0.82	0.74	16.9	16.9	0.183	0.203	0.81	0.364	Non	16.9	0.058			0.00	0.00
B-1	49	46	1	0	GC	136	2.940	2.940	0.58	1.5	1	0.98	0.82	0.70	31.8	31.8	0.457	0.507	0.76	1.023	Non	31.8	0.055			0.00	0.00
B-1	58	100	1	0	GC	136	3.480	3.480	0.54	1.5	1	0.99	0.82	0.66	66.3	66.3	0.457	0.507	0.68	1.154	Non	66.3	0.048			0.00	0.00
B-1	68	22	1	0	CL	136	4.080	4.080	0.50	1.5	1	1.00	0.82	0.61	13.4	13.4	0.145	0.161	0.60	0.410	Non	13.4	0.043			0.00	0.00
B-1	78	49	1	0	GC	136	4.680	4.680	0.46	1.5	1	1.00	0.82	0.57	27.9	27.9	0.339	0.377	0.56	1.043	Non	27.9	0.040			0.00	0.00
B-1	89	45	1	0	GM	136	5.340	5.340	0.43	1.5	1	1.00	0.82	0.53	24.0	24.0	0.267	0.296	0.52	0.872	Non	24.0	0.037			0.00	0.00
B-1	98	100	1	0	GC	136	5.880	5.880	0.41	1.5	1	1.00	0.82	0.51	50.7	50.7	0.457	0.507	0.50	1.563	Non	50.7	0.036			0.00	0.00
B-1	108	77	1	0	GC	136	6.480	6.480	0.39	1.5	1	1.00	0.82	0.48	37.2	37.2	0.457	0.507	0.49	1.607	Non	37.2	0.036			0.00	0.00
B-1	118	45	1	0	GC	136	7.080	7.080	0.38	1.5	1	1.00	0.82	0.46	20.8	20.8	0.226	0.250	0.47	0.817	Non	20.8	0.034			0.00	0.00
B-1	128	100	1	0	GC	136	7.680	7.680	0.36	1.5	1	1.00	0.82	0.44	44.4	44.4	0.457	0.507	0.46	1.699	Non	44.4	0.033			0.00	0.00
B-1	138	100	1	0	GC	136	8.280	8.218	0.35	1.5	1	1.00	0.82	0.43	42.9	42.9	0.457	0.507	0.45	1.727	Very Low	42.9	0.032			0.00	0.00
B-2	0.5	25	1	0	ML	102	0.030	0.030	2.00	1.5	1	0.75	0.82	1.85	46.1	46.1	0.457	0.507	1.00	0.780	Non	46.1	0.072			0.00	0.00
B-2	4	68	1	0	GM	102	0.240	0.240	2.00	1.5	1	0.75	0.82	1.85	125.5	125.5	0.457	0.507	0.99	0.786	Non	125.6	0.071			0.00	0.00
B-2	9	54	1	0	GC	102	0.540	0.540	1.36	1.5	1	0.75	0.82	1.26	67.8	67.8	0.457	0.507	0.98	0.795	Non	67.8	0.070			0.00	0.00
B-2	14	52	1	0	SM	102	0.840	0.840	1.09	1.5	1	0.80	0.82	1.08	55.9	55.9	0.457	0.507	0.97	0.804	Non	55.9	0.069			0.00	0.00
B-2	19	100	1	0	GM	102	1.140	1.140	0.94	1.5	1	0.86	0.82	1.01	101.0	101.0	0.457	0.507	0.96	0.813	Non	101.0	0.069			0.00	0.00
B-2	24	77	1	0	GM	102	1.440	1.440	0.83	1.5	1	0.93	0.82	0.95	73.2	73.2	0.457	0.507	0.95	0.825	Non	73.2	0.068			0.00	0.00
B-2	29	56	1	0	GM	102	1.740	1.740	0.76	1.5	1	0.96	0.82	0.89	49.8	49.8	0.457	0.507	0.93	0.843	Non	49.8	0.066			0.00	0.00
B-2	34	7	1	64	SM	102	2.040	2.040	0.70	1.5	1	0.96	0.82	0.83	5.8	11.9	0.129	0.143	0.90	0.246	Non	11.9	0.064			0.00	0.00
B-2	39	37	1	0	GC	102	2.340	2.340	0.65	1.5	1	0.97	0.82	0.78	28.7	28.7	0.365	0.406	0.86	0.726	Non	28.7	0.061			0.00	0.00
B-2	44	100	1	0	SM	102	2.640	2.640	0.62	1.5	1	0.97	0.82	0.74	73.6	73.6	0.457	0.507	0.81	0.959	Non	73.6	0.058			0.00	0.00
B-2	49	100	1	0	SM	102	2.940	2.940	0.58	1.5	1	0.98	0.82	0.70	70.2	70.2	0.457	0.507	0.76	1.023	Non	70.2	0.055			0.00	0.00
B-2	54	18	1	0	SC	102	3.240	3.240	0.56	1.5	1	0.99	0.82	0.67	12.1	12.1	0.131	0.146	0.71	0.314	Non	12.1	0.051			0.00	0.00
B-2	59	100	1	0	SM	102	3.540	3.540	0.53	1.5	1	0.99	0.82	0.65	64.8	64.8	0.457	0.507	0.67	1.169	Non	64.8	0.048			0.00	0.00
B-2	64	100	1	0	GM	102	3.840	3.840	0.51	1.5	1	1.00	0.82	0.63	62.6	62.6	0.457	0.507	0.63	1.241	Non	62.6	0.046			0.00	0.00
B-2	69	100	1	0	SM	102	4.140	4.140	0.49	1.5	1	1.00	0.82	0.60	60.5	60.5	0.457	0.507	0.60	1.308	Non	60.5	0.043			0.00	0.00
B-2	74	100	1	0	GM	102	4.440	4.440	0.47	1.5	1	1.00	0.82	0.58	58.4	58.4	0.457	0.507	0.57	1.364	Non	58.4	0.041			0.00	0.00
B-2	79	100	1	0	SC	102	4.740	4.740	0.46	1.5	1	1.00	0.82	0.56	56.5	56.5	0.457	0.507	0.55	1.414	Non	56.5	0.039			0.00	0.00
B-3	0.5	15	1	0	CL	13	0.030	0.030	2.00	1.5	1	0.75	0.82	1.85	27.7	27.7	0.338	0.372	1.00	0.671	Non	27.7	0.072			0.00	0.00
B-3	4	18	1	0	ML	13	0.240	0.240	2.00	1.5	1	0.75	0.82	1.85	33.2	33.2	0.457	0.507	0.99	0.786	Non	33.2	0.071			0.00	0.00
B-3	9	9	1	0	CL	13	0.540	0.540	1.36	1.5	1	0.75	0.82	1.26	11.3	11.3	0.122	0.136	0.98	0.213	Non	11.3	0.070			0.00	0.00
B-3	14	[illegible]	1	0	SM	13	0.840	0.809	1.11	1.5	1	0.80	0.82	1.10	36.2	36.2	0.457	0.507	0.97	0.774	Very Low	36.2	0.072			0.00	0.00
B-3	19	[illegible]	1	0	SM	13	1.140	0.953	1.02	1.5	1	0.88	0.82	1.10	46.3	46.3	0.457	0.507	0.96	0.660	Very Low	46.3	0.062			0.00	0.00
B-3	24	37	1	0	SM	13	1.440	1.097	0.95	1.5	1	0.93	0.82	1.09	40.3	40.3	0.457	0.507	0.96	0.629	Very Low	40.3	0.069			0.00	0.00
B-3	29	8	1	0	CL	13	1.740	1.241	0.90	1.5	1	0.96	0.82	1.06	8.3	8.3	0.074	0.083	0.93	0.098	Non	8.3	0.083			0.00	0.00
B-3	34	3	1	0	CL	13	2.040	1.385	0.85	1.5	1	0.96	0.82	1.00	3.0	3.0	0.056	0.061	0.90	0.072	Non	3.0	0.095			0.00	0.00
B-4	2	6	1	0	SM	63	0.120	0.120	2.00	1.5	1	0.75	0.82	1.85	11.1	11.1	0.120	0.133	1.00	0.208	Non	11.1	0.071			0.00	0.00
B-4	4	35	1	0	SC	63	0.240	0.240	2.00	1.5	1	0.75	0.82	1.85	64.6	64.6	0.457	0.507	0.99	0.786	Non	64.6	0.071			0.00	0.00
B-4	9	12	1	0	SM	63	0.540	0.540	1.36	1.5	1	0.75	0.82	1.26	15.1	15.1	0.163	0.181	0.98	0.283	Non	15.1	0.070			0.00	0.00
B-4	14	4	1	60	SM	63	0.840	0.840	1.09	1.5	1	0.80	0.82	1.08	4.3	10.2	0.110	0.122	0.97	0.194	Non	10.2	0.069			0.00	0.00
B-4	19	5	1	66	ML	63	1.140	1.140	0.94	1.5	1	0.84	0.82	1.01	5.0	11.1	0.120	0.133	0.96	0.213	Non	11.1	0.069			0.00	0.00
B-4	24	7	1	18	SM	63	1.440	1.440	0.83	1.5	1	0.93	0.82	0.95	6.7	9.6	0.103	0.114	0.96	0.186	Non	9.6	0.068			0.00	0.00
B-4	29	100	1	0	SP	63	1.740	1.740	0.76	1.5	1	0.96	0.82	0.89	88.9	88.9	0.457	0.507	0.93	0.843	Non	88.9	0.066			0.00	0.00
B-4	34	100	1	0	GC	63	2.040	2.040	0.70	1.5	1	0.96	0.82	0.83	82.7	82.7	0.457	0.507	0.90	0.869	Non	82.7	0.064			0.00	0.00
B-4	39	40	1	0	GC	63	2.340	2.340	0.65	1.5	1	0.97	0.82	0.78	31.1	31.1	0.457	0.507	0.86	0.908	Non	31.1	0.061			0.00	0.00
B-4	44	100	1	0	GC	63	2.640	2.640	0.62	1.5	1	0.97	0.82	0.74	73.6	73.6	0.457	0.507	0.81	0.959	Non	73.6	0.058			0.00	0.00
B-4	49	78	1	0	SC	63	2.940	2.940	0.58	1.5	1	0.98	0.82	0.70	54.8	54.8	0.457	0.507	0.76	1.023	Non	54.8	0.055			0.00	0.00
B-4	54	100	1	0	GC	63	3.240	3.209	0.56	1.5	1	0.99	0.82	0.68	67.7	67.7	0.457	0.507	0.71	1.064	Very Low	67.7	0.051			0.00	0.00
B-4	59	28	1	0	SC	63	3.540	3.353	0.55	1.5	1	0.99	0.82	0.67	18.7	18.7	0.201	0.223	0.67	0.487	Very Low	18.7	0.050			0.00	0.00
B-4	64	100	1	0	GC	63	3.840	3.497	0.53	1.5	1	1.00	0.82	0.66	65.6	65.6	0.457	0.507	0.63	1.130	Very Low	65.6	0.049			0.00	0.00
B-4	69	58	1	0	GC	63	4.140	3.641	0.52	1.5	1	1.00	0.82	0.64	37.4	37.4	0.457	0.507	0.60	1.149	Very Low	37.4	0.049			0.00	0.00
B-4	73	61	1	0	SC	63	4.380	3.756	0.52	1.5	1	1.00	0.82	0.63	38.7	38.7	0.457	0.507	0.58	1.160	Very Low	38.7	0.048			0.00	0.00
B-4	78	32	1	0	GC	63	4.680	3.900	0.51	1.5	1	1.00	0.82	0.62	19.9	19.9	0.216	0.239	0.56	0.562	Very Low	19.9	0.048			0.00	0.00
B-5	2	5	1	0	CL	13	0.120	0.120	2.00	1.5	1	0.75	0.82	1.85	9.2	9.2	0.101	0.112	1.00	0.172	Non	9.2	0.071			0.00	0.00
B-5	4	6	1	0	CL	13	0.240	0.240	2.00	1.5	1	0.75	0.82	1.85	11.1	11.1	0.120	0.133	0.99	0.208	Non	11.1	0.071			0.00	0.00
B-5	9	7	1	0	CL	13	0.540	0.540	1.36	1.5	1	0.75	0.82	1.26	8.8	8.8	0.096	0.107	0.98	0.167	Non	8.8	0.070			0.00	0.00
B-5	14	25	1	0	SM	13	0.840	0.809	1.11	1.5	1	0.80	0.82	1.10	27.4	27.4	0.328	0.364	0.97	0.556	Very Low	27.4	0.072			0.00	0.00
B-5	19	45	1	0	SM	13	1.140	0.953	1.02	1.5	1	0.88	0.82	1.10	49.7	49.7	0.457	0.507	0.96	0.660	Very Low	49.7	0.062			0.00	0.00
B-5	24	40	1	0	SM	13	1.440	1.097	0.95	1.5	1	0.93	0.82	1.09	43.6	43.6	0.457	0.507	0.96	0.629	Very Low	43.6	0.069			0.00	0.00
B-5	29	12	1	28	SM	13	1.740	1.241	0.90	1.5	1	0.95	0.82	1.06	12.6	18.9	0.204	0.227	0.93	0.269	Very Low	18.9	0.093			0.00	0.00
B-5	34	3	1	88	CL	13	2.040	1.385	0.85	1.5	1	0.96	0.82	1.00	3.0	8.6	0.094	0.105	0.90	0.122	Non	8.6	0.095			0.00	0.00

Applied Geotechnical Engineering Consultants, P.C.

May 10, 2005

Wasatch Regional Landfill
c/o Hansen, Allen and Luce, Incorporated
6771 South 900 East
Midvale, UT 84047

Attention: Kent Staheli
FAX: 566-5581

Subject: Response to Request for Additional Information, No. 1 (April 22, 2005)
Wasatch Regional Solid Waste Class V Landfill
Permit Modification Review
Tooele County, Utah
AGEC Project No. 1040644

Applied Geotechnical Engineering Consultants, P.C. (AGEC) was requested to provide additional information requested by the Utah Solid and Hazardous Waste Control Board for the modification to the Wasatch Regional Solid Waste Class V Landfill Permit modification.

AGEC previously conducted a geotechnical investigation for the proposed modification and presented our findings and recommendations in a report dated December 17, 2004 under Project No. 1040644.

INFORMATION REQUESTED

The letter dated April 22, 2005 (from the Utah Solid and Hazardous Waste Control Board) requests additional information on two issues that pertain to the geotechnical aspects of the modification. The additional information is requested in their Comments Nos. 14 and 15.

Item No. 14

> Page 14 states, "This acceleration was adjusted for the stability analysis as recommended in the DMG Special Publication 117 (Guidelines for Analyzing and Mitigating Landslide Hazards in California). Using this document, an acceleration of 0.092g was used for the stability calculations assuming a threshold of 15 cm displacement".

Comment

The staff has used the RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. However, the staff is not familiar with Publication 117. A copy of the publication needs to be included in the modification with a discussion of how it was applied in the model.

Response

As requested, a copy of DMG Special Publication 117 is attached.

Publication 117 was used to determine the factor, that may be applied to the maximum horizontal ground acceleration, in order to determine the horizontal coefficient that may be used in the pseudo-static stability analysis. The figure, from which the reduction factor was obtained, is included on the above referenced report on Page 10/14 within Appendix 4 (Landfill Stability). This same figure is located on Page 81 of Special Publication 117.

A factor of 0.44 was applied to the maximum acceleration to determine the horizontal acceleration coefficient with a 15 cm threshold of displacement.

Impact of the Seismic Coefficient

Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities references two methods to estimate the potential movement based on the ratio of the yield acceleration compared to the maximum design acceleration. As indicated on attached sheet 4 of 5, this ratio ranges from 0.44 to greater than 1 for the landfill. A value greater than one indicates that there would be no movement under the influence of the design acceleration. The lowest ratios (0.44 and 0.57) would indicate the potential for 17 cm (upper bound using Hynes & Franklin) to 33 cm (upper bound of Makdisi & Seed) of displacements.

The analyses with potential displacement are for the floor (17 cm) using an assumed weak strength between the HDPE and the GCL of 8 degrees. The other potential displacement (33 cm) is on the interior soil protective cover using only 50% of the available tension in the synthetic materials.

Including the analysis using the DMG Publication, it is our professional opinion that the potential displacements during a major seismic event (the design event) will be less than those estimated above due to the anticipated strengths that will most likely apply after construction (our analysis has assumed conservative strengths). Therefore, it is also our professional opinion that the landfill, as currently designed, will meet the intent of the design guidance for municipal waste landfill.

Item No. 15

Page 15 states, "The testing consisted of penetration resistances, unconfined compressive strength tests, triaxial shear tests and direct shear tests conducted on undisturbed and remolded soil samples. Based on these results, previous testing by others and our judgement, strength parameters for each material were selected.

Comment

Specific reference to test results and supporting data need to be provided to support each one of the selected parameters. As one example, strength parameters provided on Page 15 show the unit weight for waste is 120 pounds per cubic foot. The Class 5 permit application used a unit weight of 72.6 pounds per cubic foot for waste. The modification needs to include the justification for using another number.

Response

The values used for unit weight, friction and cohesion for each of the materials included in our analysis are presented in Appendix 1 of the geotechnical report (Soil Characteristics). Listed below is a summary of each of the parameters used and the source of the information.

<u>Waste</u>

a. Unit weight of 120 pounds per cubic foot

The 120 pounds per cubic foot weight for waste for was simply selected as a high value, which essentially models soil with no waste. The value included in the permit application (72.6 pounds per cubic foot) is higher than what is referenced (46 to 65 pounds per cubic foot - page 103 - Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities). The higher weight used in our analysis is conservative in that it provides a larger driving force downslope, a higher horizontal component during the seismic analysis (acceleration time the unit weight) but, also provides a higher resistance (less conservative) to sliding for frictional contacts. In order to demonstrate the impact of using 120 pcf, 72.6 pcf and 65 pcf, the landfill stability was evaluated with each of these parameters. The results are indicated below:

Unit Weight (pcf)	Static Safety Factor	Seismic Safety Factor (a = 0.21g)
65	2.478	1.225
72.6	2.452	1.212
120	2.363	1.163

As indicated by this analysis, the use of 120 pounds per cubic foot is conservative with the design.

Waste Strengths

A friction value of 25 degrees and a cohesion of 100 pounds per cubic foot were used for the strength characteristics of the waste materials. As indicated in the guidance document, the friction and the cohesion values used correspond with the lowest values included in Table 6.3 (lower bound friction angles back figured from observations of steep landfill slopes, as indicated on Page 117 of the RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. Using the lowest values will provide the more conservative analysis.

Embankment Materials

The embankment material unit weight is close to the average of on-site materials compacted to 95 percent of the maximum dry density at the optimum moisture

The strength parameters used are less than the values obtained from the laboratory tests on remolded samples of the fine-grained soil. The laboratory tests indicate a friction angle of 35 degrees with a cohesion intercept of 550 pounds per square foot. For our analysis, we have used a friction angle of 32 degrees and a cohesion of 300 pounds per square foot, (60 to 89 percent of the laboratory values).

Foundation Soil

An average unit weight of 105 pcf was used for the fine-grained foundation soil. This density is based on the typical values obtained from laboratory tests. The density is based on the typical values obtained from laboratory tests. The values can be seen on Sheet 4 of 6 of Appendix 1 of the geotechnical report.

The strength of the fine-grained soil was tested in the laboratory. The results are summarized on Sheet 3/6 within Appendix 1 (Soil Characteristics). An average friction angle of 31.6 degrees and an average cohesion of 43 pounds per square foot were obtained. With these values, we have used a friction angle of 31 degrees and a cohesive intercept of 40 pounds per square foot, (93 to 98 percent of the laboratory average).

Natural Gravel

A unit weight of 130 pounds per cubic foot for the gravel was used in our analysis. This value is slightly less than the value obtained in the laboratory. The values obtained are shown on Sheet 4 of 6 of Appendix 1 (Soil Characteristics) of the geotechnical report.

The strength of the granular soil was determined by evaluating the penetration resistance values (Sheet 5 of 6, Appendix 1) along with correlation of penetration resistance versus friction angle. The values obtained during our study was significantly greater than those obtained by Kleinfelder. It is our professional opinion that the higher values are due to the fact that our borings were further up the hill, sampling denser material. A friction value of 37 degrees was, therefore, selected and used in the analysis.

It is our professional opinion that the values used in the analysis are representative of the materials that will be in place and used during construction. These values are appropriate for modeling of the conditions that will be experienced.

If you have any questions or we can be of further service, please call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

REGISTERED PROFESSIONAL ENGINEER
5/10/05
STATE OF UTAH

James E. Nordquist, P.E.
JEN/sc
Enclosures

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 5/7/05 BY [illegible]

SUBJECT Stability w/ Waste weights (different) SHEET 1 OF

Overall landfill stability

- As previously presented at 120 pcf waste unit weight

File	Condition	S.F.
WRL.I9	Static w/ Waste γ = 65 pcf	2.496
WRL.I10	" " γ = 72.6 pcf	2.465
WRL.I11	" " γ = 120 pcf	2.353
WRL.I12	Dynamic, a = 0.11 g, waste 120 pcf	1.157
WRL.I13	" " " 72.6 pcf	1.214
WRL.I14	" " " 65 pcf	1.227

Summary - The 120 pcf is more conservative.

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 5/7/05 BY [illegible]

SUBJECT Seismic SHEET 2 OF

Three conditions resulted in Seismic S.F. ~ 1.3.

Floor

$$S.F. = \frac{\cos 0.97}{\sin 0.97 + K \cos 0.97} \tan \phi$$

w/K = 0.0925 S.F. = 1.28
= 0.21 S.F. = 0.62
= 0.12 S.F. = 1.0

ratio of $K_y / K_{max} = \frac{0.12}{0.21} = 0.57$

Exterior Side w/o cohesion

$$S.F. = \frac{\cos 14.04}{\sin 14.04 + K \cos 14.04} \tan 23.9$$

w/K = 0.0925 S.F. = 1.29
= 0.21 S.F. = 0.96
= 0.19 S.F. = 1.0

ratio of $K_y / K_{max} = 0.19/0.21 = 0.92$

Interior Cover w/ 50% of geosynthetic tensile

@ 10' K_{yield} = 0.18 ratio = 0.18/0.21 = 0.84
@ 20' K_{yield} = 0.0925 ratio = = 0.44

Applied Geotechnical Engineering Consultants, P.C.

PROJECT NO. 1040644 TITLE WRL DATE 5/17/05 BY [illegible]

SUBJECT Seismic SHEET 3 OF

Summary

Location		Acceleration Yield	Acceleration Max	Y/m	Makdisi	Hynes mean+σ	Hynes Upper Bound
Entire Landfill		>0.21	0.21	>1	0	0	0
Floor		0.12	0.21	0.57	2 - 15 cm	<10cm	$\boxed{17cm}$
Exterior Side w/o cohesion		0.19	0.21	0.90	$\boxed{0.05 - 0.3\ cm}$	<10cm	<10cm
Interior Cover 50% tension	10'	0.18	0.21	0.86	0.1 - 0.65 cm	<10cm	$\boxed{<10cm}$
	20'	0.0925	0.21	0.44	4 - $\boxed{33\ cm}$	<10cm	26cm

Sheet 4/

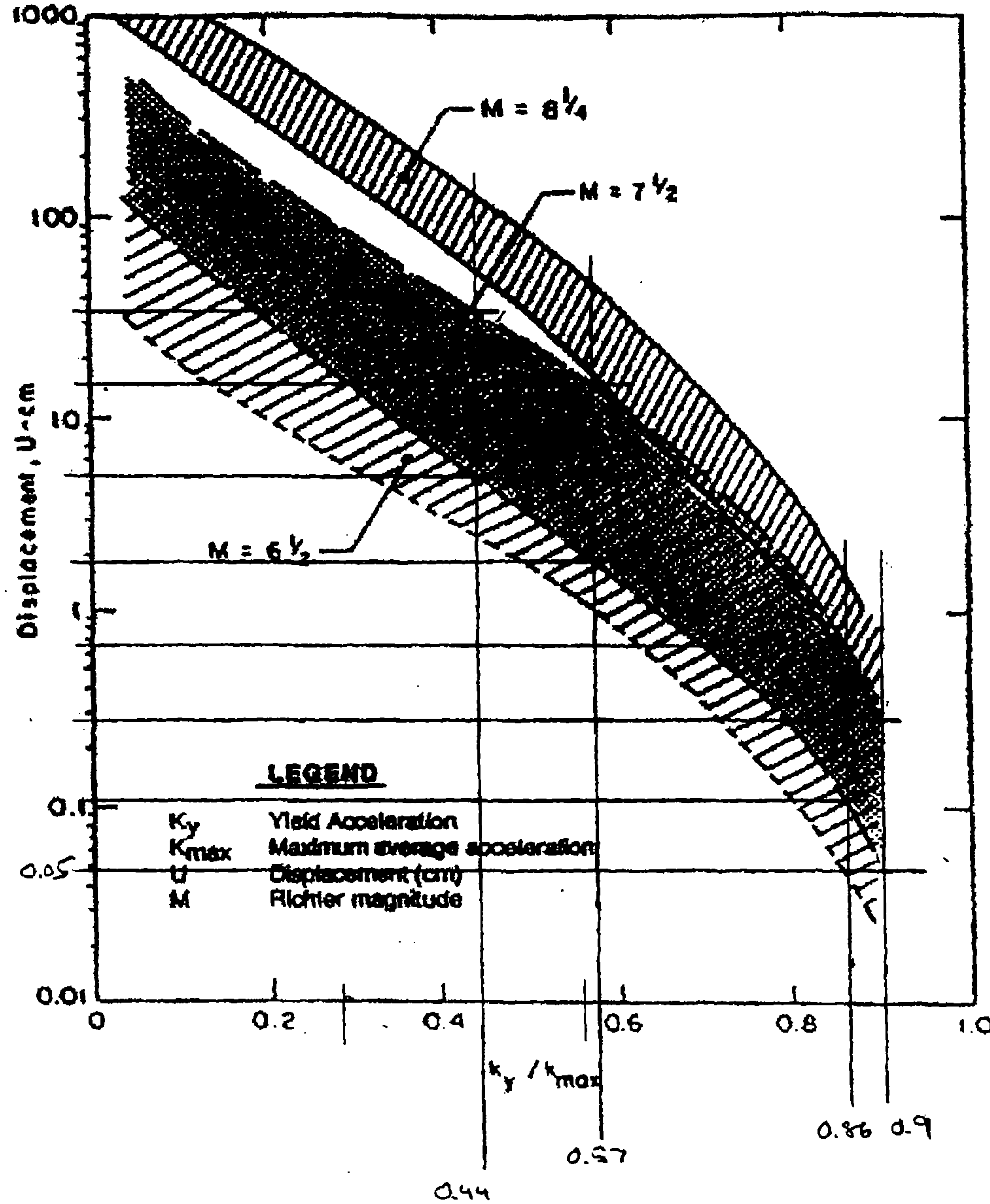


Figure 6.6 Makdisi and Seed Permanent Displacement Chart (Makdisi and Seed, 1978).

Sheet 51

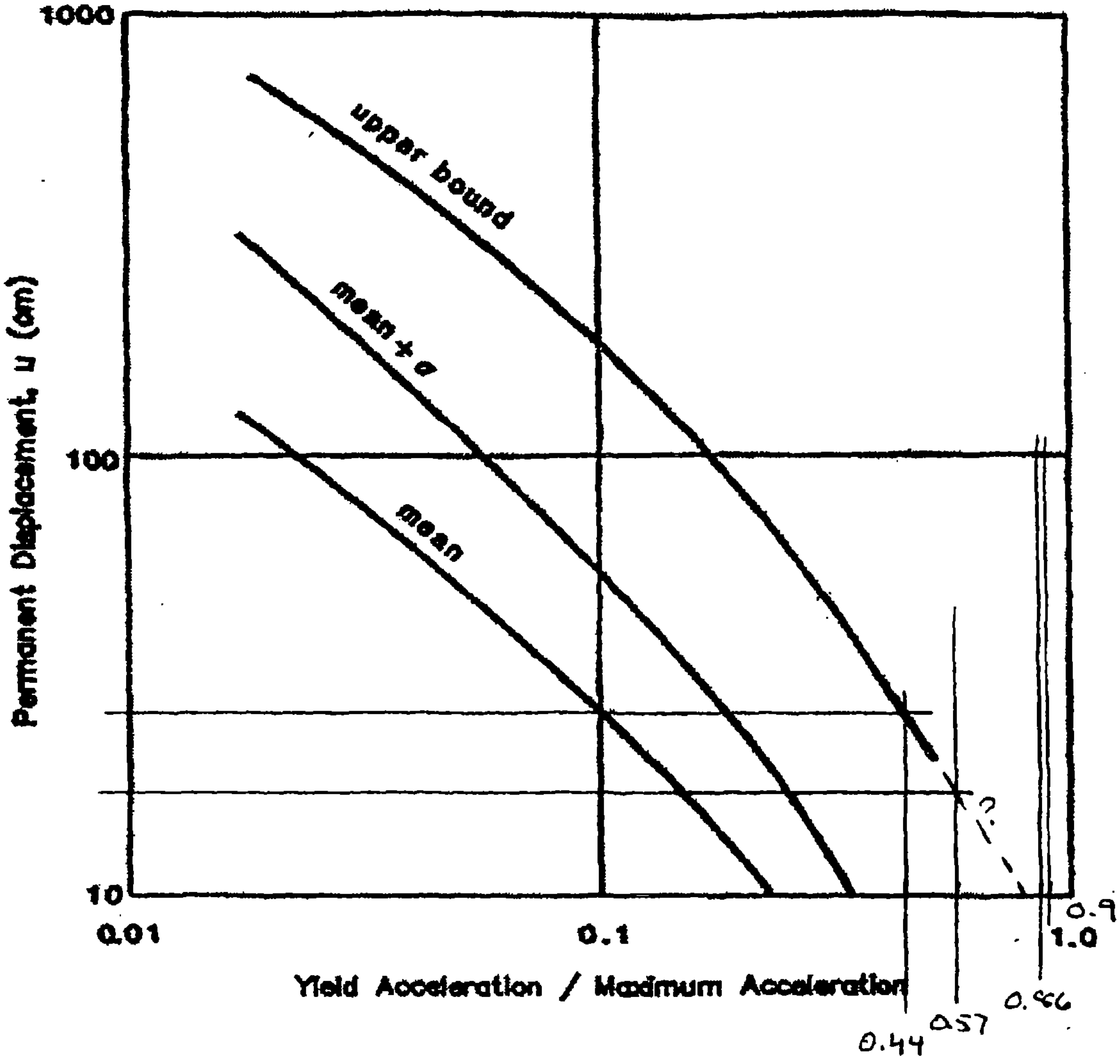
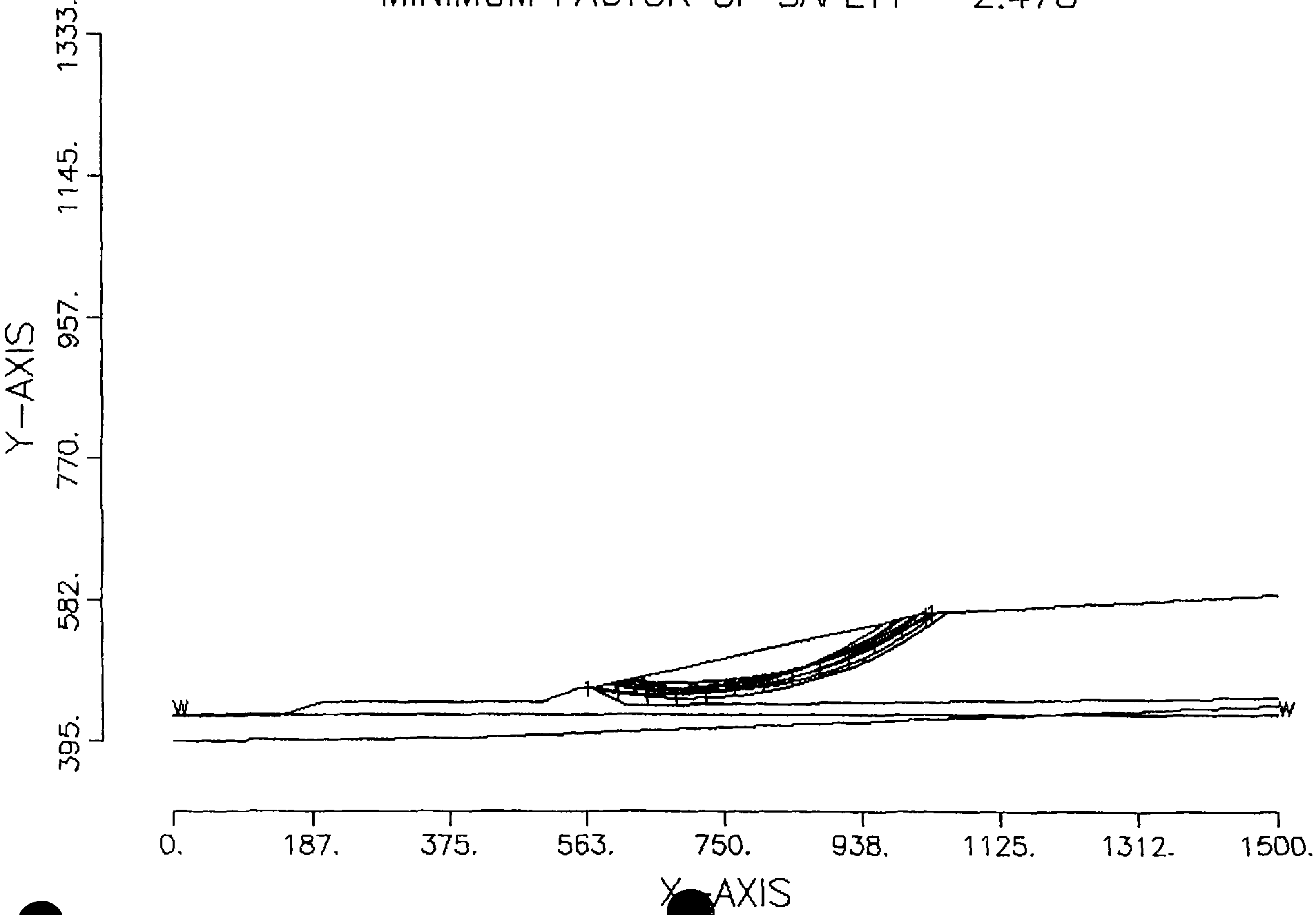


Figure 6.5 Hynes and Franklin Permanent Seismic Displacement Chart (Hynes and Franklin, 1984).

AG[
Midvale UT s/n5206

Wasatch Regional Landfill,Waste Slope,
Static Analysis,Waste=65pcf,WRL.I9
2500SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.478



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200. 448. 500. 448. 2
500. 448. 551. 465. 2
551. 465. 571. 465. 2
571. 465. 1021. 565. 1
1021. 565. 1500. 590. 1
571. 465. 613. 444. 2
613. 444. 1500. 453. 2
0. 395. 400. 400. 3
400. 400. 1500. 443. 3
SOIL
3
65. 65. 100. 25. 0. 0. 1
105. 105. 40. 31. 0. 0. 1
130. 130. 0. 37. 0. 0. 1
WATER
1 62.4
2
0. 430.
1500. 430.
CIRCL2
50 50 450. 800. 950. 1400.
1. 40. 0. 0.
END
```

AGI
Midvale UT s/n5206

Wasatch Regional Landfill,Waste Slope,St
atic Analysis,Waste=72.6pcf,WRL.I10
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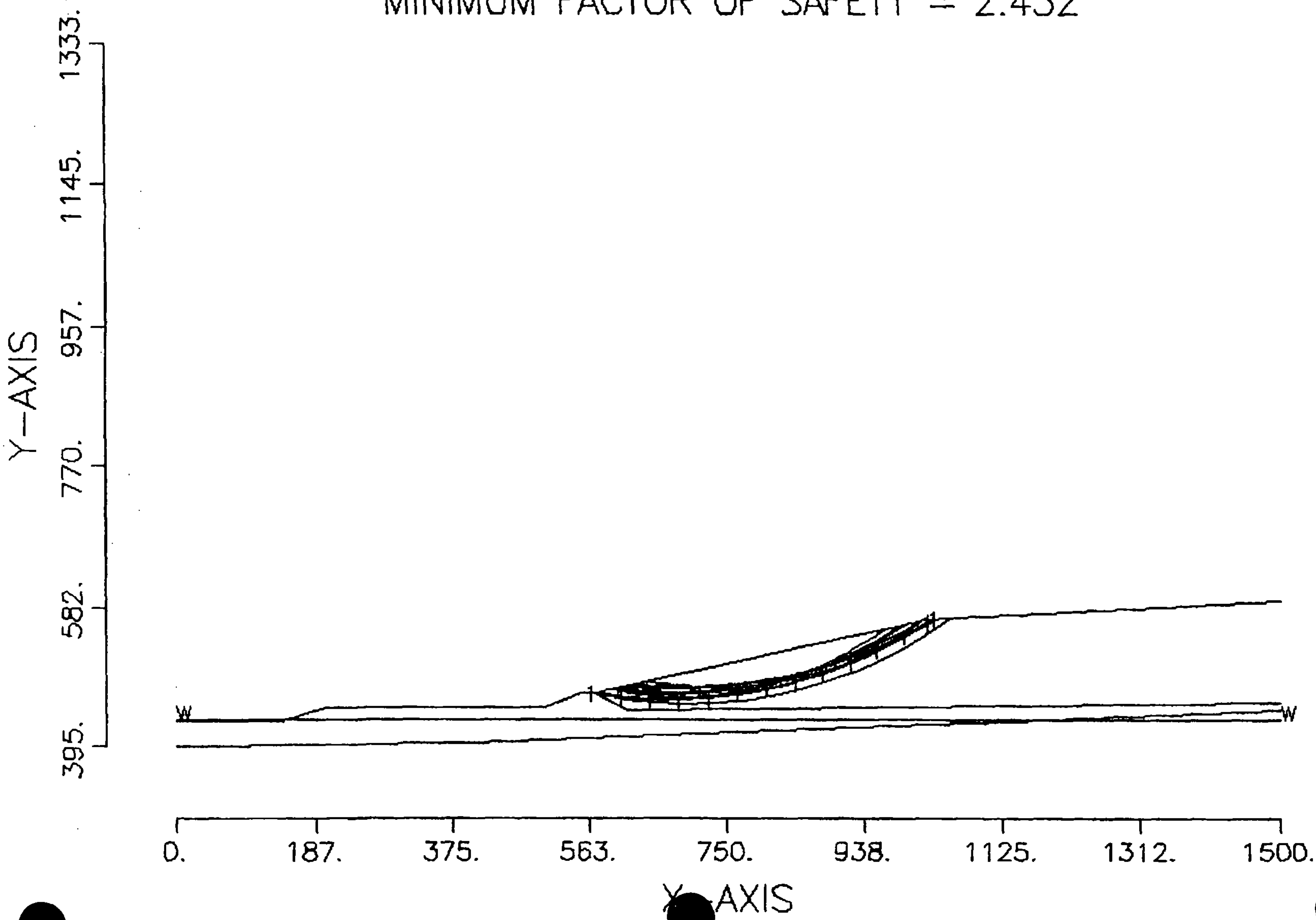
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.452



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PROFILE
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[illegible] 428. 200. 448. 2
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500. 448. 551. 465. 2
551. 465. 571. 465. 2
571. 465. 1021. 565. 1
1021. 565. 1500. 590. 1
571. 465. 613. 444. 2
613. 444. 1500. 453. 2
0. 395. 400. 400. 3
400. 400. 1500. 443. 3
SOIL
3
72.6 72.6 100. 25. 0. 0. 1
105. 105. 40. 31. 0. 0. 1
130. 130. 0. 37. 0. 0. 1
WATER
1 62.4
2
0. 430.
1500. 430.
CIRCL2
50 50 450. 800. 950. 1400.
1. 40. 0. 0.
END
```

AGF
Midvale UT s/n5206

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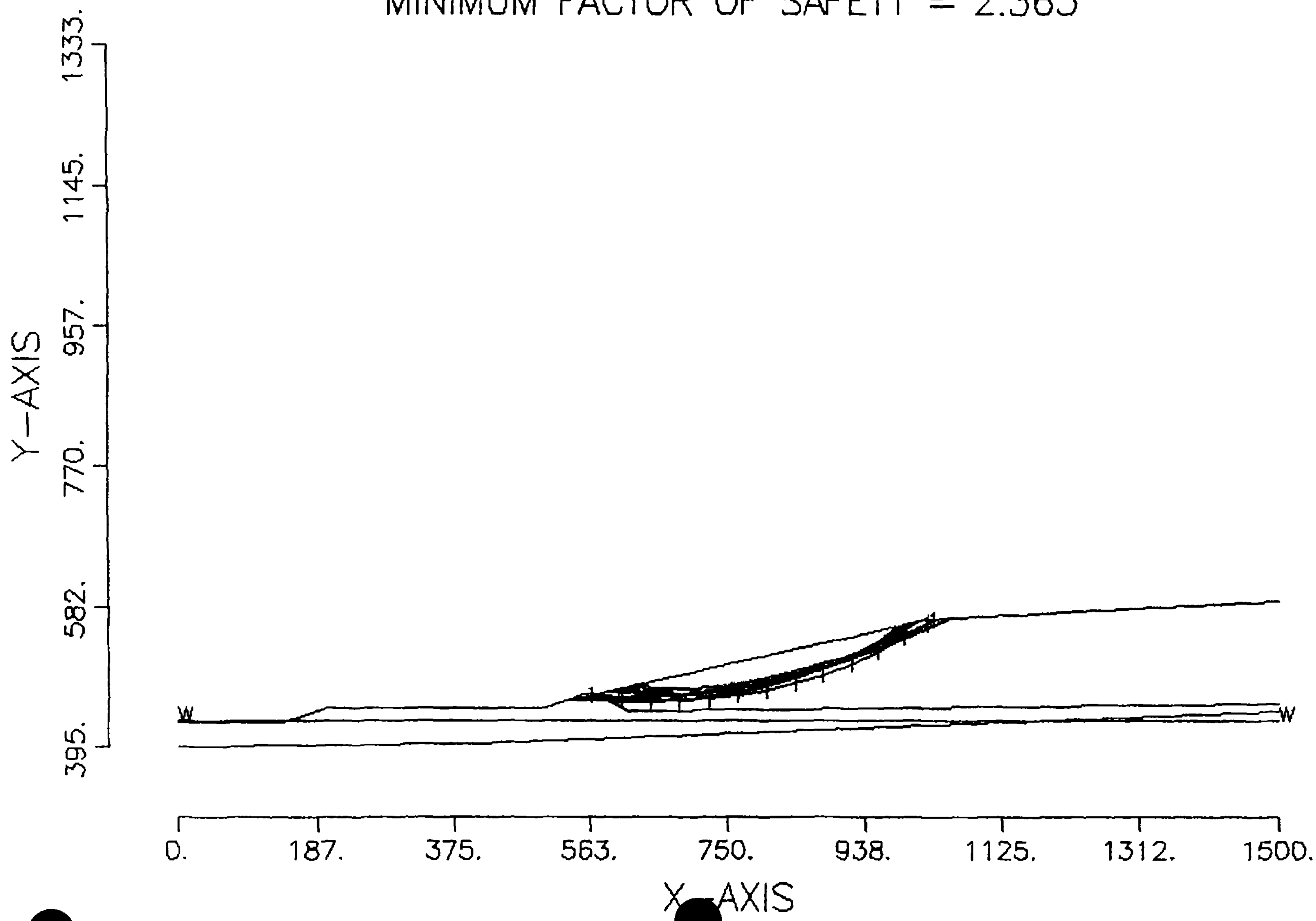
MINIMUM FACTOR OF SAFETY = 2.363



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500. 448. 551. 465. 2
551. 465. 571. 465. 2
571. 465. 1021. 565. 1
1021. 565. 1500. 590. 1
571. 465. 613. 444. 2
613. 444. 1500. 453. 2
0. 395. 400. 400. 3
400. 400. 1500. 443. 3
SOIL
3
120. 120. 100. 25. 0. 0. 1
105. 105. 40. 31. 0. 0. 1
130. 130. 0. 37. 0. 0. 1
WATER
1 62.4
2
0. 430.
1500. 430.
CIRCL2
50 50 450. 800. 950. 1400.
1. 40. 0. 0.
END
```

AGF
Midvale UT s/n5206

Wasatch Regional Landfill,Waste Slope,Dynamic Analysis,Waste=65,a=0.21g,WRL.I14
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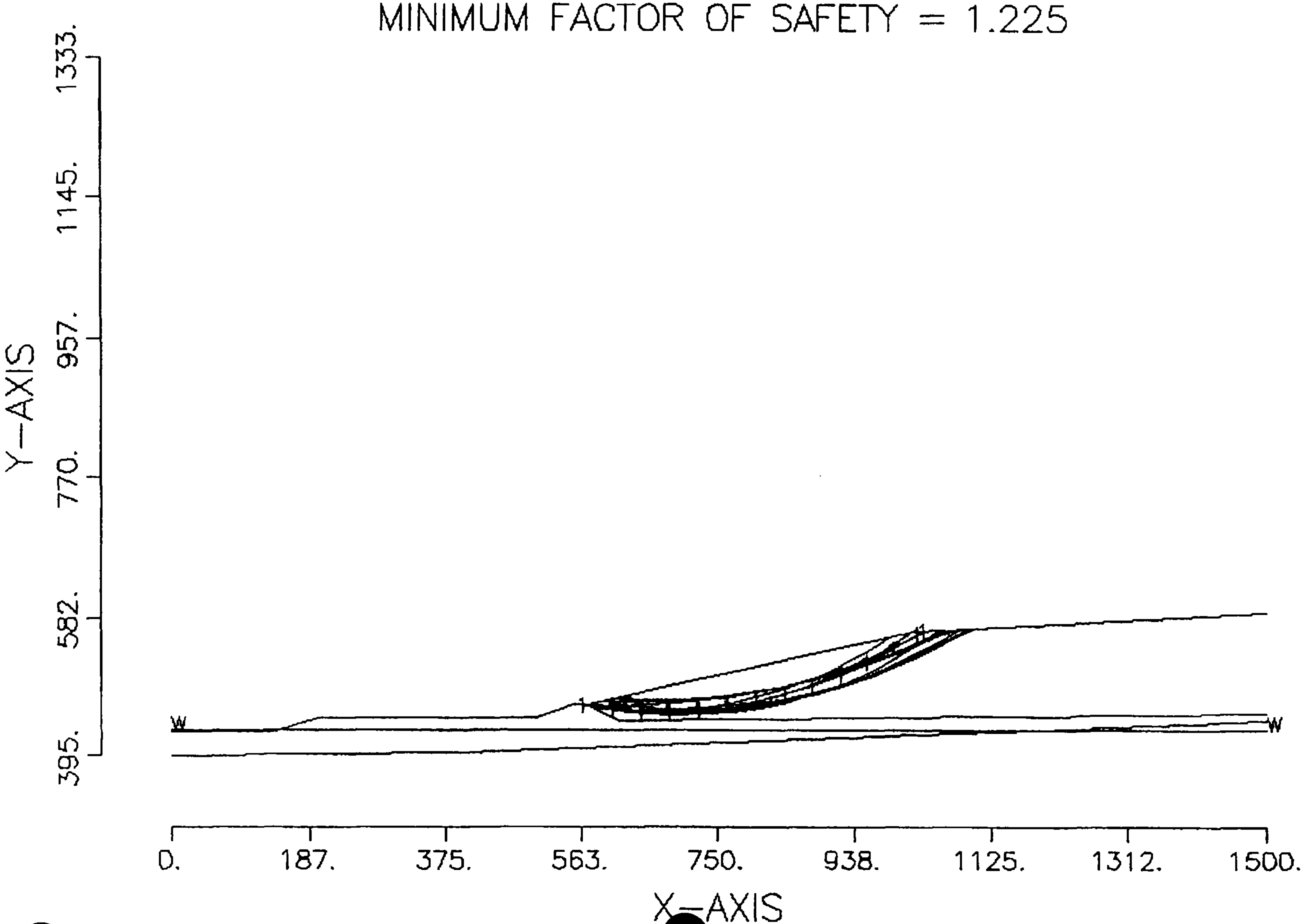

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500. 448. 551. 465. 2
551. 465. 571. 465. 2
571. 465. 1021. 565. 1
1021. 565. 1500. 590. 1
571. 465. 613. 444. 2
613. 444. 1500. 453. 2
0. 395. 400. 400. 3
400. 400. 1500. 443. 3
SOIL
3
65. 65. 100. 25. 0. 0. 1
105. 105. 40. 31. 0. 0. 1
130. 130. 0. 37. 0. 0. 1
WATER
1 62.4
2
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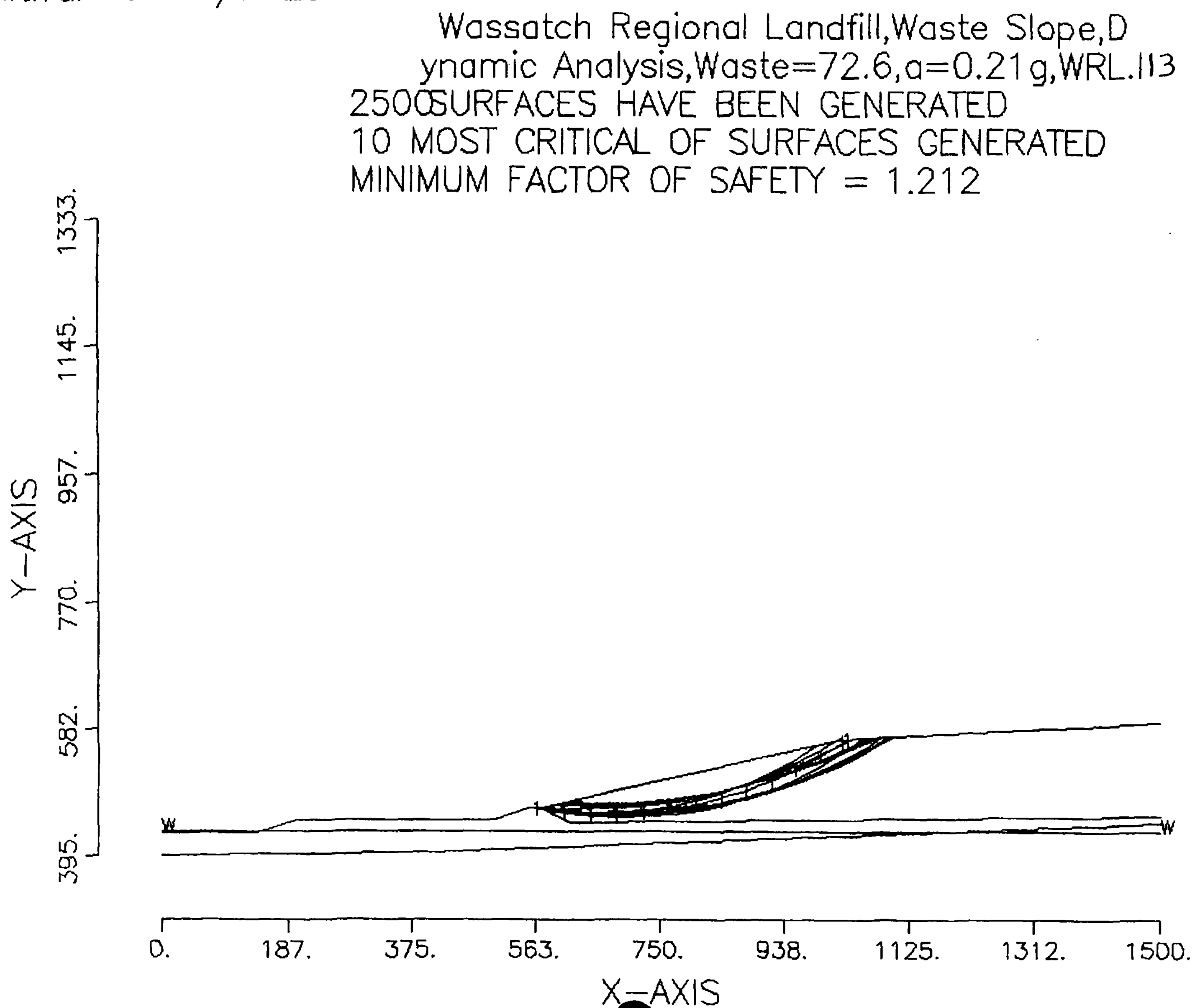

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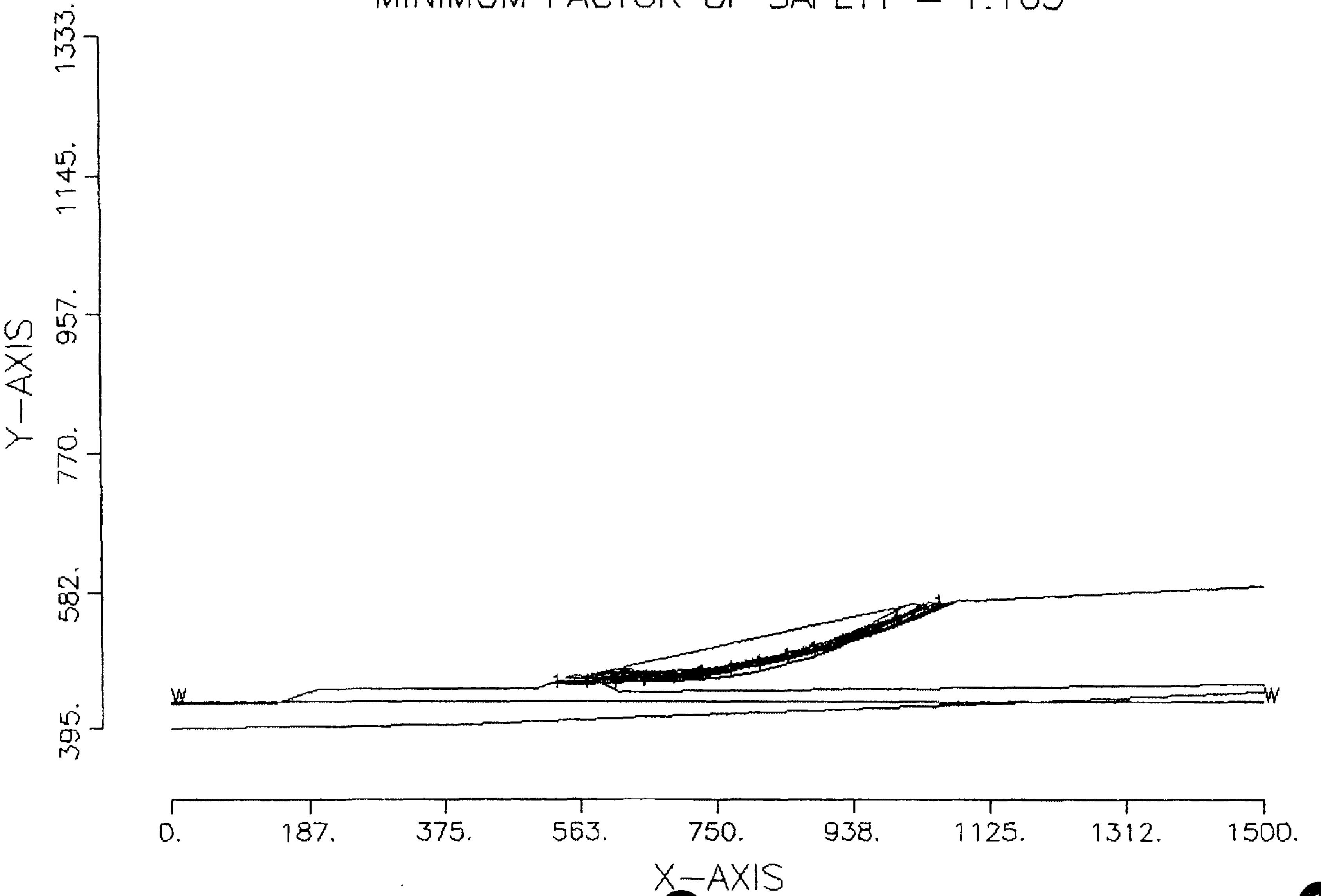

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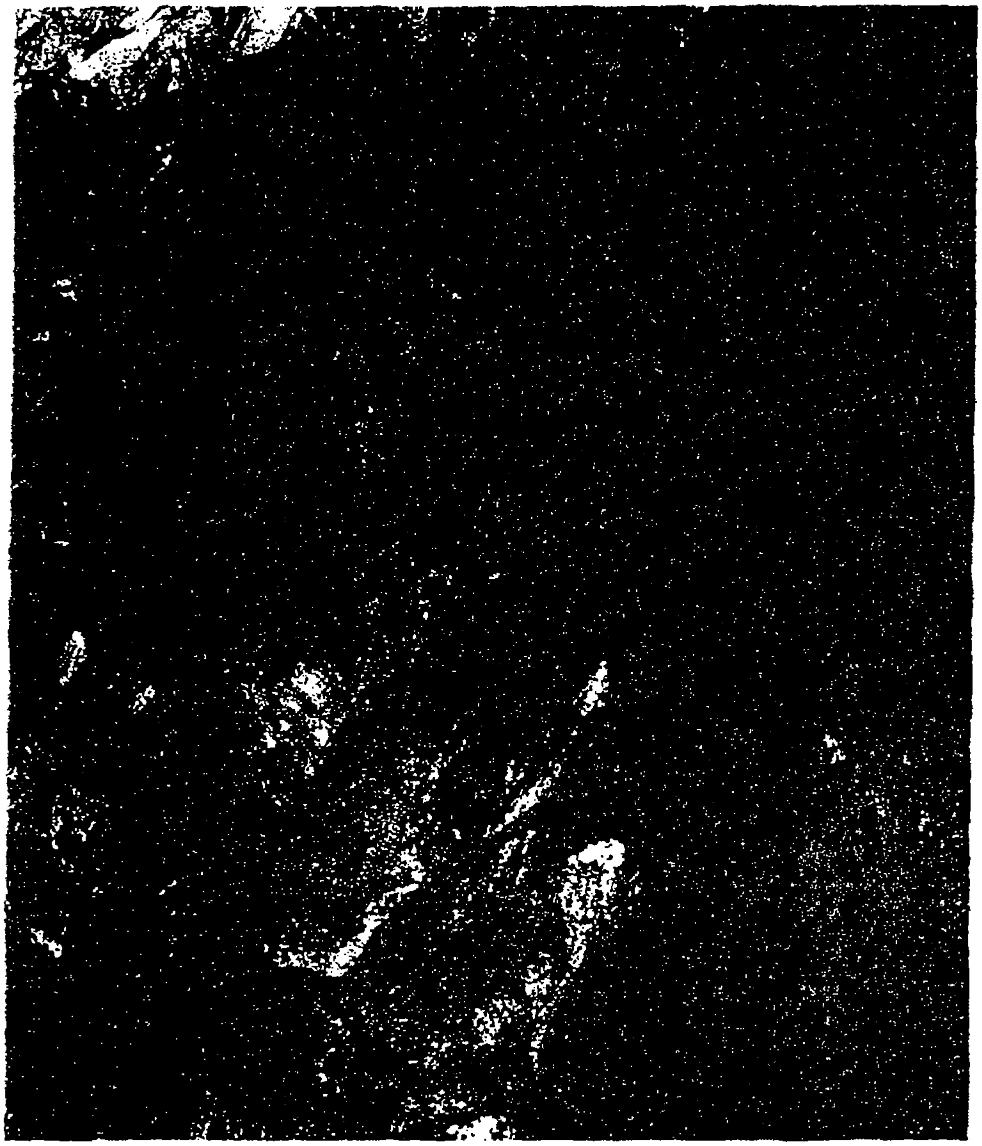


RECOMMENDED PROCEDURES FOR IMPLEMENTATION OF DMG SPECIAL PUBLICATION 117 GUIDELINES FOR ANALYZING AND MITIGATING LANDSLIDE HAZARDS IN CALIFORNIA

ASCE

Committee organized through the
ASCE Los Angeles Section Geotechnical Group
Document published by the
Southern California Earthquake Center

SCEC

Publication of this document was funded by the Southern California Earthquake Center.

The Southern California Earthquake Center (SCEC), headquartered at the University of Southern California, is a regionally focused organization founded in 1991 with a mission to gather new information about earthquakes in Southern California, integrate knowledge into a comprehensive and predictive understanding of earthquake phenomena, and communicate that understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives. Funding for SCEC activities is provided by the National Science Foundation (NSF) and the U.S. Geological Survey (USGS). An outstanding community of scientists from over 40 institutions throughout the country participates in SCEC. The SCEC Communication, Education, and Outreach Program offers student research experiences, web-based education tools, classroom curricula, museum displays, public information brochures, online newsletters, and technical workshops and publications.

The cover photograph depicts a landslide that developed in the Ramona oilfield, north of San Martinez Grande Canyon, about 9 km east-northeast of Piru, California. The landslide is 600 m long, 100-150 m wide, and has an estimated volume of about 1 million cubic meters. During the Northridge earthquake (January 17, 1994), the landslide moved downslope about 15-25 meters. (Photograph courtesy of Randall Jibson, U.S. Geological Survey)

June 2002

The over 3-1/2 years effort of the committee members to study, evaluate, discuss, and formulate these guidelines is greatly appreciated. The summation of those consensus efforts is presented in this report.

The committee was organized by the southern California section of the Association of Civil Engineers and the City and County of Los Angeles Departments of Building and Safety and Public Works. The committee has, however, performed its work independent of those entities. The document represents the work of the committee. Although the document has been peer reviewed, the information and opinions presented are those of the committee and have not been endorsed by ASCE, SCEC, or the City or County of Los Angeles.

Appreciation is given to those who have taken their time to review this document and have provided many wise comments and suggestions: Professors Jonathan D. Bray and Raymond B. Seed of U.C. Berkeley, Professors Ellen M. Rathje and Stephen G. Wright of the University of Texas at Austin, Dr. Leland M. Kraft, Dr. Neven Matasovic, Dr. Edward Kavazanjian, Dr. Marshall Lew, Boris O. Korin, Allan E. Seward, and Larry K. Stark. Review comments were also made by John A. Barneich, S. Thomas Freeman, Yoshi Moriwaki, Sarkis V. Tatusian, and John T. Waggoner of GeoPentech and Robert A. Larson, County of Los Angeles.

Two factors that are particularly challenging to characterize accurately are subsurface stratigraphy/geologic structure and soil shear strength. Subsurface characterization requires a thorough exploration program of borings, cone penetration tests, and/or trenches, and must identify the potentially critical soil zones. Characterization of representative soil shear strength parameters is an especially difficult step in slope stability analyses due in part to the heterogeneity and anisotropy of soil materials. Furthermore, the strength of a given soil is a function of strain rate, drainage conditions during shear, effective stresses acting on the soil prior to shear, the stress history of the soil, stress path, and any changes in water content and density that may occur over time. Due to the strong dependence of soil strength on these factors, methods of soil sampling and testing (which can potentially alter the above conditions for a tested sample relative to in-situ conditions) are of utmost importance for slope stability assessments.

This report provides guidelines on each of the above-enumerated factors, with particular emphasis on subsurface/geologic site characterization, evaluation of soil shear strength for static and seismic analysis, and seismic slope stability analysis procedures.

1.2 APPLICABLE REGULATIONS AND LAWS

The State of California currently requires analysis of the seismic stability of slopes for certain projects. Most counties and cities in southern California also require analysis of the static stability of slopes for most projects. The authority to require analysis of seismic slope stability is provided by the Seismic Hazards Mapping Act of 1990, which became California law in 1991 (Chapter 7.8, Sections 2690 et. seq., California Public Resources Code). The purpose of the Act is to protect public safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure; or other hazards caused by earthquakes. The Seismic Hazards Mapping Act is a companion and complement to the Alquist-Priolo Earthquake Fault Zoning Act, which addresses only surface fault-rupture hazards. Chapters 18 and 33 (formerly 70) of the Uniform/California Building Code provide the authority for local Building Departments to require geotechnical reports for various projects.

Special Publication 117 (SP 117), by the California Department of Conservation, Division of Mines and Geology in 1997, presents guidelines for evaluation of seismic hazards other than surface fault-rupture and for recommending mitigation measures. The guidelines in SP 117 provide, among other things, definitions, caveats, and general considerations for earthquake hazard mitigation, including seismic slope stability.

SP 117 provides a summary overview of analysis and mitigation of earthquake induced landslide hazards. The document also provides guidelines for the review of site-investigation reports by regulatory agencies who have been designated to enforce the Seismic Hazards Mapping Act.

presented in Chapter 11 represent the consensus recommendations of all practicing and academic members of the Committee (regulatory officials chose not to vote). The Committee was unable to reach consensus on acceptable seismic slope displacements, and therefore regulatory agencies will need to establish their own values for this important parameter.

The Committee actively sought input from professional and academic sources across the U.S., and this report reflects the valuable input from those individuals.

1.3 LIMITATIONS

Ground deformations under static and seismic conditions can result from a variety of sources, including shear and volumetric straining. This report focuses on slope stability and seismic slope displacements, both associated with shear deformations in the ground. Ground deformations associated with volume change, such as hydrocompression or consolidation under long-term static conditions or seismic compression during earthquakes, are not covered by the actions of this committee. In addition, ground displacements associated with post-seismic pore pressure dissipation in saturated soil, or lateral spread displacements in liquefied ground, are not covered.

The intent of this report is to present practical guidelines for static and seismic slope stability evaluations that blend state-of-the-art developments in methodologies for such analyses with the site exploration, sampling, and testing techniques that are readily available to practicing engineers in the southern California area. Accordingly, the intent is not necessarily to present the most rigorous possible procedures for testing the shear strength of soil and conducting stability evaluations, but rather to suggest incremental rational modifications to existing practice that can improve the state-of-practice. It should be noted that the Committee by no means intends to discourage the use of more sophisticated procedures, provided such procedures can be demonstrated to provide reasonable solutions consistent with then-current knowledge of the phenomena involved.

Adverse bedding conditions (out-of-slope bedding) and shear strength values representing the weaker materials (such as shale interbeds in a predominantly sandstone formation) within the mapped geologic unit are considered in the rock-strength grouping. If geotechnical shear test data are insufficient or lacking for a mapped geologic unit, the unit is grouped with lithologically and stratigraphically similar units for which shear strength data are available.

Based on calibration studies (McCrink, in press), hillslopes exposed to ground motions that exceed the yield acceleration for instability, and are associated with displacements greater than 5 cm are included in Earthquake-Induced Landslide Zones. The ground motion parameters used in the analysis include mode magnitude, mode distance, and peak acceleration for firm rock. Expected earthquake shaking is estimated by selecting representative strong-motion records, based on estimates of probabilistic ground motion parameters for levels of earthquake shaking having a 10 percent probability of being exceeded in 50 years (Petersen et al., 1996).

Seismic Hazard Zones for potential earthquake-induced landslide failure are presented on 7.5-minute quadrangle sheet maps at a scale of 1:24,000. Supplementary maps of rock strength, adverse bedding, geology, ground motions, and an evaluation report describing strength classification, Newmark displacements and regional geology and geomorphology are also provided for each quadrangle as the basis for delineation of the zones. The zone maps do not identify other earthquake-triggered slope hazards including ridge-top spreading and shattered ridges. Run-out areas of triggered landslides may extend outside the landslide zones of required investigation.

Seismic Hazard Zone maps are being released by the California Department of Conservation, Division of Mines and Geology. The maps present zones of required investigation for landslide and liquefaction hazards as determined by the criteria established by the Seismic Hazards Mapping Act Advisory Committee.

to the potential impact of the subsurface geologic structure, stratigraphy, and hydrologic conditions on the stability of the slope. The assessment of the subsurface stratigraphy and hydrologic conditions of sites underlain solely by alluvial materials may be performed by the geotechnical engineer. The shear strength and other geotechnical earth material properties should be evaluated by the geotechnical engineer. The geotechnical engineer should perform the stability calculations. The ground motion parameters for use in seismic stability analysis may be provided by either the engineering geologist or geotechnical engineer, or a registered geophysicist competent in the field of seismic hazard evaluation.

4. Presentation and analysis of the data, including an evaluation of the potential impact of geologic conditions on the project.

Geologic reports should demonstrate that each of those phases has been adequately performed and that the information obtained has been considered and logically evaluated. Minimum criteria for the performance of each phase are described and discussed below.

4.1 BACKGROUND RESEARCH

The purpose of background research is to obtain geologic information to identify potential regional geologic hazards and to assist in planning the most effective surface mapping and subsurface exploration program. The availability of published references varies depending upon the study area. Topographic maps at 1:24,000 scale are available for all of California's 7.5' quadrangles. More detailed topographic maps are often available from Cities or Counties. Most urban locations in California have been the subject of regional geologic mapping projects. Other maps that may be available include landslide maps, fault maps, depth-to-subsurface-water maps, and seismic hazard maps. Seismic slope stability hazard maps prepared by the California Division of Mines and Geology (CDMG) are particularly relevant, and the location of a site within in a seismic slope stability hazard zone will generally trigger the type of detailed site-specific analyses that are the subject of this report. The above maps are typically published by the United States Geological Survey (USGS), CDMG, Dibblee Geological Foundation, and local jurisdictional agencies (e.g., Seismic Safety elements of cities and counties). Collectively, these maps provide information useful for planning a geologic field exploration. In addition, the maps provide insight into regional geologic conditions (and possible geologic constraints) that may not be apparent from focused site studies.

Review of unpublished references also should be a part of geologic studies for slope stability. Previous geologic and geotechnical reports for the property and/or neighboring properties can provide useful data on stratigraphy, location of the groundwater table, and shear strength parameters from the local geologic formations. Strength data should be carefully reviewed for conformance with the sampling and testing standards discussed in sections 6 and 7 before being used. Critical review of topographic maps prepared in conjunction with proposed developments can reveal landforms that suggest potential slope instability. These materials are usually kept by the local jurisdictional governing agency, and review of their files is recommended.

Once review of available geologic references has been performed, aerial photographs of the area should be reviewed. Often, the study of stereoscopic aerial photographs reveals important information on historical slope performance and anomalous geomorphic features. Because of differences in vegetative cover, land use, and sun angle, the existence of landslides or areas of potential instability is sometimes visible in some photographs, but not in others. Therefore, "going into the field." The number of borings required is a function of the areal extent of the development, available information from previous investigations, and the complexity of the geologic features being investigated. Sound geologic and engineering judgment is required to estimate the number of borings required for a specific site. Guidelines on minimum level of exploration necessary for various types of construction are presented in NAVFAC 7.01 (1986). In general, it is anticipated that the number of borings/trenches should not be less than three. Additional borings will be required in many cases when the geology is complex. Borings should be positioned such that extrapolation of geologic conditions is minimized within the areas of interest.

The depth of borings and test pits should be sufficient to locate the upper and lower limits of weak zones potentially controlling slope stability. It should be noted that movement of landslides can be accommodated across multiple slip surfaces. Accordingly, locating the shallowest potential slide plane at a site may not be sufficient. In general, the depth of exploration should be sufficiently deep that the static factor of safety of a slip surface passing beneath the maximum depth of exploration and through materials for which appropriate presumptive strength values are assumed is greater than 1.5.

As noted above, continuous logging of subsurface materials is generally required to locate zones of potential weakness. Downhole logging is commonly practiced in southern California, and is widely thought to be the most reliable procedure. Downhole observation of borings provides an opportunity for direct sampling of potentially critical shear zones or weak clay seams. Such sampling and subsequent laboratory testing can be used to estimate strengths along potential slip surfaces. Prevailing conditions such as the presence of subsurface water, bad air, or caving soil may make it unsafe or impractical to enter and log exploratory borings. In those circumstances, it is necessary to utilize alternative methods such as continuously cored borings, conventional borings with continuous sampling, or geophysical techniques. Although those methodologies may be useful, the data obtained from them have limitations as geologic conditions are inferred rather than directly observed. Therefore, when such methods are utilized, the limitations should be compensated for by more subsurface exploration, more testing, more conservative data interpretation, and/or more comprehensive engineering analysis.

Detailed and complete logs of all subsurface exploration should be provided in geologic reports. Written descriptions of field observations should be accompanied by graphic logs that depict the geologic units, subsurface water conditions at the time of drilling and any subsequent measurements, and information relevant to soil sampling (e.g., sampler used, driving system, blow count, etc.) (ASTM D1586 and D6066-98).

landslide slip surfaces, and lines that represent interpretation of bedding planes, joints, or fractures. Sections that clearly show interpretation of geologic structure are necessary for subsequent engineering evaluation of stability because the ultimate determination of potential failure planes for analyses is dependent upon the accuracy of those sections. Because geologic structure is so critical to the evaluation of slope stability, potential modes of failure should be identified by the geologist, and evaluation of the most critical modes of failure should be a made by both the geologist and geotechnical engineer.

1. By the use of total unit weights and specification of groundwater table location and boundary water pressures. This method is appropriate for effective stress analyses of slope stability and should be used with effective stress strength parameters. [If a total stress analysis is desired, it should be performed with no phreatic surface (i.e., zero pore pressure). Seepage forces should not be included. Total stress strength parameters should be used.]

2. By the use of buoyant unit weights and seepage forces below the water table. This method is appropriate for use only with effective stress analyses; it should not be used with total stress analyses.

Method 1 is most commonly selected. In a stability analysis utilizing Method 1, pore-water pressures are commonly depicted as an actual or assumed phreatic surface or through the use of piezometric surfaces or heads. The phreatic surface, which is defined as the free subsurface water level, is the most common method used to specify subsurface water in computer-aided slope stability analyses. The use of piezometric surfaces or heads, which are usually calculated during a seepage or subsurface water flow analysis, is generally more accurate, but not as common. Several programs will allow multiple perched water levels to be input within specific units through the specification of piezometric surfaces.

denser, therefore, stiffer and stronger than the in-situ soil. The converse is also true, namely a dilatant sample will decrease in density as a result of the sampling process; therefore, the tested specimen will be weaker than the in-situ soil.

6.2 SELECTION OF AN APPROPRIATE SAMPLING TECHNIQUE

It follows from the above reasoning that the sampling techniques that impart the least shear strain to the soil are most desirable. Commonly available sampling techniques include: (1) driven thick-walled samplers advanced by means of hammer blows, (2) pushed thin-walled tube samplers advanced by static force, and (3) hand-carved samples obtained from a bucket-auger hole or test pit.

Two types of thick-walled driven samplers are most often used in practice: (1) Standard Penetration Test (SPT) split spoon samplers, which have a 2.0-inch outside diameter and 5/16-inch wall thickness, and (2) so-called California samplers, which typically have a 3.0- to 3.3-inch outside diameter, 1/4- to 3/8-inch wall thickness, and internal space for brass sample tubes (which typically are stacked in 1.0-inch increments).

Pushed thin-walled tube samplers are typically 3 to 5 inches in diameter with an approximately 1/16 to 1/8-inch-thick walls. When configured with a 3.0-inch outside diameter and advanced with a simple static force, they are referred to as Shelby tubes (ASTM D1587). A sampler that provides less sample disturbance than Shelby tubes is a Hydraulic Piston Sampler (e.g., Osterberg type). It is often not possible to penetrate cohesionless soil or stiff cohesive soil with Shelby tubes, and in such cases a Pitcher tube configuration can be used. The sample tube used in a Pitcher tube sampler is identical to a Shelby tube, but the tube is advanced with the combination of static force and cutting teeth around the outside tube perimeter, which descend to the base of the tube when significant resistance to penetration is encountered.

Hand-carved samples are generally retrieved by removing an intact block of soil, which is transported to the laboratory. The sample is carefully trimmed in the laboratory to the size required for testing. Disturbed bulk samples can also be hand collected for remolding in the laboratory.

The selection of a sampling method for a particular soil should take into consideration the disturbance associated with field sampling as well as transportation and laboratory sample handling. Tube samplers require specimen extrusion and trimming, whereas the brass rings used in California samplers can be directly inserted into direct shear or consolidation testing equipment.

be cleansed of contaminating materials and remolded for subsequent testing in the laboratory (see Section 7.3.3(b)ii).

5. A conservative estimate of strengths along unweathered joint surfaces in rock masses can be obtained by pre-cutting in the laboratory an intact rock specimen and shearing the sample in a direct shear device along the smooth cut surface. The strength obtained from the pre-cut sample is generally a conservative estimate because actual joint surfaces have asperities not present in the lab specimen. Alternatively the rock may be repeatedly sheared without pre-cutting the sample. The objective in sampling for this type of testing is therefore an intact rock specimen, with the "joint" surface being created parallel to the direction of testing. Such samples can be obtained by coring, hand carving, or driving samples in non-brittle rocks.

6. Intact rock should be sampled by coring or hand carving to preserve sample integrity. California samples of intact rock will generally be fractured and significantly disturbed. Accordingly, shear strengths obtained from testing of specimens obtained with California samples will generally be lower than the actual strength of the in situ intact rock.

7. For new compacted fills, bulk samples of borrow materials can be obtained for re-molding and compacting in the laboratory.

8. Soil containing significant gravel generally can be sampled by hand carving of large specimens or correlations with penetration resistance can be used to estimate strengths. Correlations with penetration resistance are based on SPT blow counts or Becker penetrometer blow counts. Andrus and Youd (1987) describe a procedure to determine N-values in soil deposits containing significant gravel fragments. They suggest that the penetration per blow be determined and the cumulative penetration versus blow count be plotted. Changes in the slope of the plot indicate that gravel particles interfered with sampler penetration. Estimates of the effective penetration resistance of the soil matrix can be made for zones where the gravel particles did not influence the penetration.

6.3 SPACING OF SAMPLES

For most projects, samples from borings should be obtained at maximum 5-foot vertical intervals or at major changes in material types (whichever occurs more frequently). Samples in heterogeneous or layered materials should be obtained as often as needed to reflect the variability of the deposit and retrieve samples of the weakest materials that might influence slope stability. Larger sample-spacing intervals can be used for deep borings drilled primarily to obtain information on geologic structure

Table 7.1. Summary of Recommended Strength Evaluation Procedures

Site Condition	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fine-grained soft alluvium loaded by fill	Undrained	Total	Peak	Reduce peak strength by 30%	UTC (UU or CU) Vane Shear	Undrained, total stress, UTC (UU or CU), use judgment for pk. v. residual
Coarse-grained alluvium loaded or unloaded (unsaturated)	Drained	Effective	Peak	None	DDS, DTC	Effective Stress, drained, DDS, DTC
Coarse-grained alluvium, loaded or unloaded (saturated)	Drained	Effective	Peak	Check for liquefaction potential	DDS, DTC	Effective Stress, drained, DDS, DTC; use undrained residual strength if liquefiable
Saturated, fine-grained, overconsolidated, stiff alluvium or clayey bedrock with massive or supported bedding, Loaded	Undrained (check drained)	Total	Peak	Reduce peak strength by 30%	UTC	Undrained, total stress parameters, rate adjusted peak strengths
Unloaded	Drained	Effective	Depends on LL and CF	None	DDS, DTC (see Comment 3)	
Heavily overconsolidated saturated clay or clayey bedrock - pre-existing shear surfaces, loaded or unloaded	Drained	Effective	Residual	None	DDS, RS	Effective Stress, Drained DDS, RS

For the rapid stress application that occurs during earthquake shaking, shearing occurs under undrained conditions. For that condition, the following types of strength parameters are recommended:

- Clay: Total-stress strength parameters from undrained test (CU or UU)
- Clay at residual: Effective-stress strength parameters, drained or undrained test
- Sand, unsaturated: Effective-stress drained strength parameters
- Sand, saturated: See below

For saturated sands, the pore pressure generated during shaking should be estimated with a liquefaction analysis. The undrained residual strength should be used if the soil liquefies, which can be estimated using available correlations with penetration resistance (i.e., Fig. 7.7 of Martin and Lew, 1999). A drained strength should be used if the soil does not liquefy, but the pore pressure generated during shaking should be estimated, so that the effective stress in the soil can be appropriately reduced.

The criteria in the "Seismic" column of Table 7.1 can be applied to the selection of strengths for seismic stability analyses. The principal comments associated with those criteria are as follows:

With respect to strain-softening effects, initial analyses can be performed with peak strengths. However, if slope displacement analyses indicate significant shear deformations in the slope, strengths should be reduced to values between peak and residual (depending on the soil characteristics and the amount of the computed displacement).

As discussed in Section 7.2.4, rate effects tend to increase the undrained strength of fine-grained materials, but may be partially offset by cyclic strength degradation effects.

7.2 GENERAL CONSIDERATIONS

7.2.1 Drainage Conditions and Total vs. Effective Stress Analysis

Soil behavior during drained loading is fundamentally different than during undrained loading. Drained loading implies that loads are applied at a sufficiently slow rate that no pore pressures are generated in the soil during shear, and volume change is allowed. Brinch-Hansen (1962) referred to this as "consolidated-drained" or CD loading, and that nomenclature will be used here. Undrained loading refers to a shear condition in which no volume change occurs, accordingly increased pore pressures will be generated in saturated, contractive soil, and decreased pressures in saturated, dilatent soil. Undrained shear can occur immediately after construction, or upon loading that follows consolidation of the soil. These cases are referred to

The undrained shear strength of soil also can be described using effective stress strength parameters, but this is seldom done in routine practice because the use of such parameters in design would require an evaluation of pore-pressure response in the field during construction, which is a non-trivial analysis. Accordingly, shear strengths from UU or CU tests are typically defined using alternative strength parameters. End-of-construction (UU) strengths are described using conventional total stress strength parameters, i.e.,

$$\tau_{ff} = c + \sigma_{f,f} \tan\phi \text{ (end-of-construction, UU)} \quad (7.1b)$$

where σ_{ff} = total normal stress on the failure plane at failure. This linear approximation is only appropriate over a fairly short range of normal stresses. For saturated soil, ϕ=0 in Eq. 7.1b, and the strength is often denoted as $\tau_{ff} = s_u$ or $\tau_{ff} = c$. As illustrated in Fig. 7.2, these strength parameters are generally obtained with triaxial testing, as sample drainage cannot readily be controlled in direct shear tests. As indicated in the figure, triaxial tests are performed at a cell pressure σ_{cell}, and the shear strength τ_{ff} is obtained as half the deviatoric stress ($2q_f$).

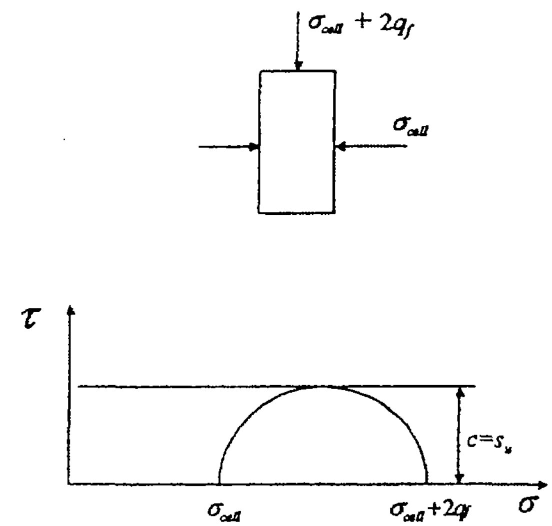


Figure 7.2. Stress State at Failure in Triaxial UU Test

As described by Casagrande and Wilson (1960) and Ladd (1991), post-consolidation, undrained (CU) strengths are evaluated by first consolidating the soil to a specified effective consolidation stress, σ_c', and then shearing the soil rapidly to failure. The shear stress on the failure plane at failure (τ_{ff}) is best evaluated by plotting the Mohr Circle in effective stress space, as shown

5. Unloading of soft clay may be critical under short-term undrained or long-term drained conditions. Strengths representative of both conditions should be evaluated for stability analyses.

For saturated or nearly saturated soils, rapid stress application during earthquake shaking occurs as undrained loading. Accordingly, either total stress or CU strength parameters should be used. If, prior to the probable earthquake, effective stresses in the soil can be expected to change with time due to consolidation, it may be reasonable to use CU strengths based on effective consolidation stresses that will be present in the slope after the completion of some acceptable amount of consolidation. Assuming the construction being analyzed involves loading of the ground, the range of effective possible consolidation stresses that could be chosen is, as a minimum, the effective consolidation stress prior to construction, and as a maximum, the effective consolidation stress after all excess pore pressures from loading have dissipated. The choice of which consolidation stress within this range should be used is project-specific, and should be selected after discussion between the consultant and regulatory official. Conversely, clayey soil subject to unloading will swell over time, and the reduced effective stresses present after the completion of swell should be used for seismic design.

Negative pore pressures are present in unsaturated soils. Limited experimental and centrifuge studies have shown that at saturation levels of 88% and 44%, these negative pore pressures may rise (i.e., become less negative) during rapid cyclic loading (Sachin and Muraleetharan, 1998; Muraleetharan and Wei, 2000). The available information is far from exhaustive, but those studies preliminarily suggest that at the pre-shaking saturation levels considered, the pore pressures can rise to nearly zero, but are unlikely to become positive. That behavior is less likely to occur in materials with higher degrees-of-saturation (for example, > 90%), because the relative scarcity of air bubbles could lead to the development of positive pore pressures. Accordingly, for materials that can be expected to have moderate saturation levels (< 90%), an assumption of zero pore pressure in the soil is likely to be conservative, meaning that stability analyses can be performed using effective stress strength parameters derived from drained shear tests. Those strength parameters should be used with effective stresses calculated for a zero pore pressure condition (i.e., effective stress = total stress).

7.2.2 Post-Peak Reductions in Shear Strength

All limit equilibrium methods for slope stability assume a rigid-perfectly plastic soil stress-deformation response, as depicted in Fig. 7.3. Because this model assumes strength to be independent of deformation, it can be difficult to apply to soil subject to post-peak reductions in shear capacity (i.e., soil with strength that is dependent on the level of deformation). Many soils strength is measured (i.e., intact specimen for ultimate; reconstituted specimen for fully softened).

The above strength terms are used in the context of drained shear. Undrained specimens can also experience strain softening, often due to pore pressure increase and/or particle re-orientation. For undrained shear, we will only refer to two strength values - peak and residual.

Skempton (1985) reports that fully softened/ultimate and residual drained shear strengths are approximately equivalent for materials with clay contents less than 25% (with clay defined as material finer that 0.002 mm). Drained residual strengths are less than fully softened strengths for materials with higher clay contents.

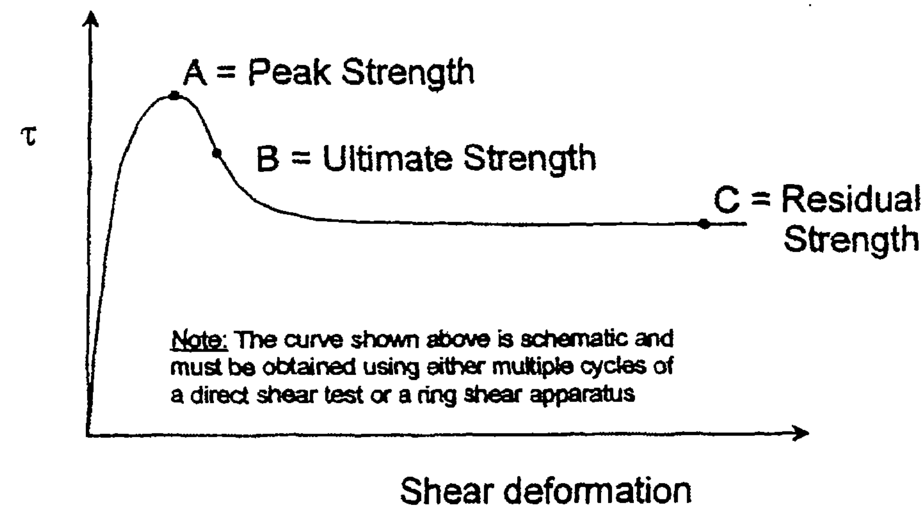


Figure 7.4. Diagrammatic Stress-Displacement Curve

Many materials can experience a post-peak reduction in strength, including most clayey soil (under drained or undrained conditions), dense sand under drained conditions, loose sand under undrained conditions, and cemented soil.

The following guidelines apply to the selection of appropriate strength parameters in materials subject to strain softening during long-term, drained loading conditions.

1. Residual strengths should be used in materials that have experienced significant previous shear deformations. Examples include materials located along pre-existing landslide slip surfaces and along continuous bedding planes likely to have been subject to significant past movement (e.g., folded bedrock that may have experienced flexural slip along bedding planes). Residual strengths should be used in those materials, even if the relative movement across the discontinuity occurred thousands of years ago (Skempton and Petley, 1967).

slope failure mechanisms at the site, and strain compatibility of shear strengths for materials along the failure surface.

Recommendations 3, 5, and 6 above are based on comparisons of mobilized shear strength (established from back analyses of first time slides) to fully softened and residual shear strengths by Stark and Eid (1997), and updated by Stark and McCone (2001). The Committee recognizes that ground conditions at the sites considered by Stark and Eid (1997) may not be directly comparable to materials that weather from older bedrock (pre-Quaternary). It is, however, the consensus of the Committee that these recommendations represent the best approach currently available. With respect to Recommendation 4 (weathered soil), the samples tested for Atterberg limits and shear strength should be taken from naturally weathered deposits of a similar earth material at or near the site. To distinguish between the levels of plasticity referred to above, visual classifications can be used in lieu of formal Atterberg Limits testing.

For undrained loading of clayey soil, Ladd (1991) found back-calculated values of $\tan(\Psi_u)$ from field case histories to be similar to laboratory CU test results adjusted for strain compatibility effects. The laboratory CU parameters for which these comparison were made represent peak strengths, hence, it is inferred that strain-compatibility adjusted peak strengths can be used for field applications. Strain compatibility adjustments to peak shear strength are discussed in Section 4.9 of Ladd (1991).

7.2.3 Soil Anisotropy

Stress and fabric induced anisotropy, as well as pre-existing shear zones, can lead to shear strengths that are dependent on the orientation of the failure plane. Slopes with pre-existing shear zones should be analyzed using along-bedding and across-bedding strengths applied to relevant portions of the failure surface (guideline #4 for sampling along bedding is included in Section 6.2).

For relatively homogeneous alluvial soil subjected to undrained loading, laboratory testing that shears samples across horizontal planes (such as triaxial tests on specimens retrieved from vertically advanced samplers) generally provide unconservatively high estimates of shear strength along the actual failure surface in the field (Duncan and Seed, 1966a and 1966b). Such effects are less significant for homogenous soil subjected to drained loading (Mitchell, 1993).

7.2.4 Rate Effects

Laboratory shear tests are generally performed over the course of minutes to days. Field loading under static loading is much slower, whereas seismic loading is more rapid.

strain rates can be used as a first-order approximation of the residual strength friction angle under undrained and rapid loading conditions.

7.2.5 Effect of Confining Stress on Soil Failure Envelope

The effect of confining stress on the stress-strain response of granular materials has been summarized by Lambe and Whitman (1969) as follows:

1. As confining pressure increases, the peak normalized shear strength (i.e., secant friction angle based on peak strength) decreases.

2. The fully softened/ultimate strength is more-or-less independent of changes in confining pressure.

The strong effect of confining pressure on normalized peak shear strengths has been attributed to a decreased tendency for dilation at large confining pressures, and a reduced level of grain interlocking (and increased grain crushing) as confining pressures increase (Lambe and Whitman, 1969; Terzaghi et al., 1996). This reduction of friction angle with increasing confining pressure causes downward curvature of the failure envelope.

For clayey soil, Skempton (1985) and Stark and Eid (1994) have found downward curvature of failure envelopes representing the residual strengths, and Stark and Eid (1997) have found downward curvature of failure envelopes for fully softened strength. Therefore, curvature of failure envelopes is an issue faced in both cohesive and cohesionless materials. At low confining pressures, curvature can be particularly pronounced, as failure envelopes for residual strength pass through or nearly through the origin

Given the above, it is important to perform shear strength testing across the range of normal stresses expected in the field. A curved representation of the failure envelope can be used in many modern computer programs, and is the preferred method for accounting for these effects. If this is not possible, a linear representation of the actual curved failure envelope can be used across the range of normal pressures expected in the field. It should be noted, however, that, in situations where both shallow and deep-seated stability must both be analyzed, more than one linear envelope would need to be established.

At sites with particularly deep-seated slip surfaces, it may not be possible to perform testing at the normal pressures occurring in the field. In such cases, testing should be performed across a range of lower normal stresses to establish the variation of friction angle with increased stress. This variation can be described in terms of power, cycloid, and hyperbolic equations (Duncan et al., 1989; Atkinson and Farrar, 1985; Maksimovic, 1989; Vyalov, 1986). These expressions can

7.3.1 Presumptive Values

Conservative presumptive shear strength parameters can be used in slope stability analyses for sites where no field exploration or laboratory testing have been performed. Because these presumptive strength parameters are used in lieu of site-specific exploration or testing, they must be chosen conservatively, so that the probability that lower strength parameters exist at a site is very low. In general, presumptive values should be selected and approved by local regulatory reviewing agencies in a manner that incorporates data from local case histories, experimental data, and back analyses. These values apply only for the drainage conditions, loading rates, etc. that were present in the tests/case studies from which the values were derived. Provided they are used for a comparable set of conditions, presumptive strength parameters should yield a safe design, but not necessarily an economical one. For most projects, it should be economically beneficial to perform field exploration and laboratory testing to develop project-specific shear strength parameters rather than use low, presumptive strength values. It also should be noted that presumptive strength parameters are intended to be realistic lower bound strength values and are not intended to be lower than any values ever obtained.

7.3.2 Published Correlations

As described previously in Section 6.2, in most cases the drained strength of sand and non-plastic silt is best estimated by correlations with SPT blow count and CPT tip resistance. The recommended SPT correlation for sand is shown in Fig. 7.5a. Note that the blow count [$(N_1)_{60}$] is corrected for procedure to 60% efficiency, and corrected to 1.0 atm overburden pressure. CPT tip resistance is also normalized to 1.0 atm overburden pressure in the correlation shown in Fig. 7.5b. SPT and CPT procedure and overburden correction factors are discussed in detail in Martin and Lew (1999).

Evaluation of the drained or undrained shear strength of clay should be accomplished with testing. However, it is good practice to check laboratory-derived strength parameters for clay using available correlations. A particularly onerous problem with clay strength evaluations can be the evaluation of residual shear strengths for thin failure surfaces. This problem arises principally from difficulty in sampling and properly orienting test specimens in direct shear devices. Accordingly, it is strongly recommended that sufficient clay be obtained by scraping the surface to allow determination of the liquid limit and clay fraction, so that the residual shear strengths for clay slip-surfaces can be checked using published correlations such as those by Stark and McCone, 2001 (updated from Stark and Eid, 1994 and 1997). Correlations between soil liquid limit and clay fraction (established by a ball-milling technique) and friction angle are shown in Figures 7.5c (residual friction angle) and 7.5d (fully softened friction angle). Care should be exercised when using these correlations because liquid limits and clay contents derived

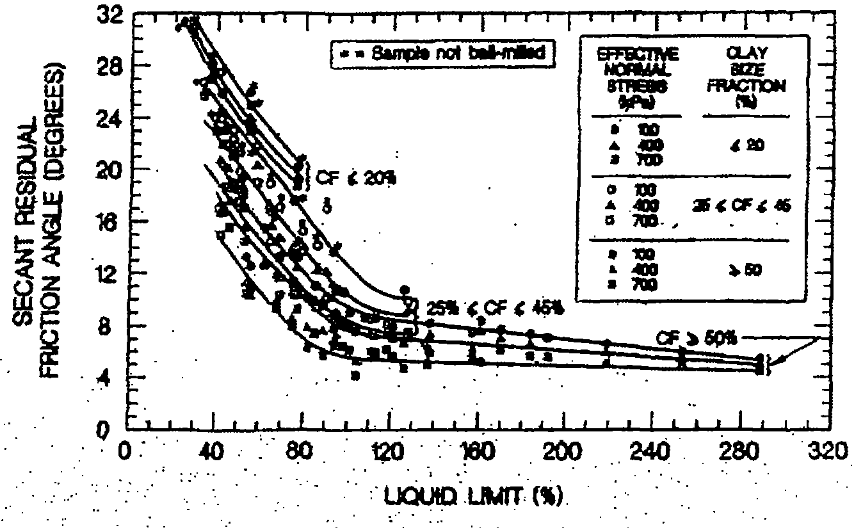


Figure 7.5c. Empirical Correlation Between Drained Residual Friction Angle of Fine-Grained Soil and Ball-Milled Liquid Limit (Stark and McCone, 2001)

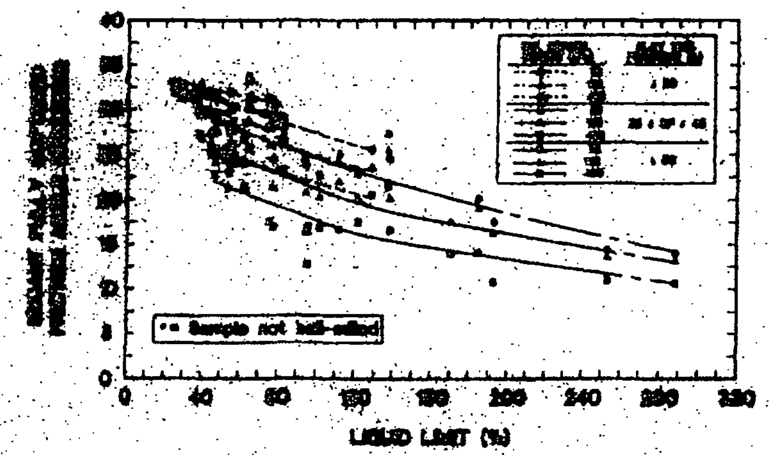


Figure 7.5d. Empirical Correlation Between Fully Softened Friction Angle of Fine-Grained Soil and Ball-Milled Liquid Limit (Stark and McCone, 2001)

7.3.3 Laboratory Testing

(a) General Considerations

Laboratory testing can be used to evaluate the load-deformation response and shear strength of soil samples. Laboratory equipment available for shear-strength testing includes the following:

- The triaxial compression test (TC) is a relatively common laboratory test that can be used for the evaluation of drained or undrained shear strength parameters. The applied load is measured in terms of deviatoric stresses, and deformation is measured in terms of axial strains.

- Unconfined compression tests are simply UU triaxial compression tests with zero cell pressure. Unconfined compression tests are only useful for crude estimation of total stress strength parameters, and tend to provide conservative results. These strengths can generally be applied only for an "unconsolidated" condition (i.e., no field consolidation since sample retrieval), and only for the location in the ground from which the sample was retrieved.

- The direct shear test (DS) is the most commonly used shear strength test due to its operational simplicity. In southern California, the test is often run on specimens retrieved from California samplers, which (as noted in Section 6.2) are likely to be significantly disturbed. DS test results for such specimens are very approximate. In the DS test, applied load is measured in terms of shear stress, and deformation is measured in terms of shear displacement (not strain). The ASTM procedure for this test is formulated to achieve drained shear. True undrained conditions cannot be obtained because pore pressures dissipate during shear. The direct shear test controls the location of shearing and is therefore useful for testing specific failure surfaces. DS testing devices can be used to subject a sample to multiple cycles of shearing, which allows an estimation of residual strength. Unfortunately, the results may be unconservative (Watry and Lade, 2000), and should always be checked against either correlations (Stark & McCone, 2001) or results of ring shear testing (discussed below).

- Ring shear tests can be used to estimate the residual strengths corresponding to large displacements in reconstituted (bulk) samples. Ring shear devices cannot be used with undisturbed soil specimens from the sampler types discussed in Section 6.0.

- Although mostly research tools at this point, direct simple shear and torsional shear testing provides a reliable means of evaluating either undrained or drained stress-strain response of soil.

endorse such practice. Furthermore, the absence of an ASTM standard for that test makes it a non-standard test that in practice will vary in procedure and quality from consultant to consultant, and one that has not benefited from a comprehensive review and comparison with truly undrained tests. Although this committee cannot endorse such a practice, some Committee members believe that the appropriate regulatory agencies have the power to decide under which testing conditions (if any) rapid, so-called "undrained" direct shear tests can be used to estimate undrained strength parameters in their individual jurisdictions. Other Committee members believe that the use of rapid deformation rates in the direct shear test device (in an effort to approximate undrained strength parameters) should not be allowed at this time, because it can lead to unreasonable and unconservative estimates of the undrained shear strength.

The following guidelines should be adhered to so that the test results can be used for slope stability analyses.

1. The dry density and moisture content prior to shear should be determined. That can be achieved by measuring the weight of the ring sample prior to testing and determining the moisture content using an adjacent ring.

2. Samples tested for static stability analyses should be saturated unless the engineer can convincingly demonstrate that saturation of the soil during the design life of the slope is unlikely. Samples tested for seismic stability analyses may be tested at field moisture conditions that are likely to exist at the time of the earthquake. For non-irrigated slopes, that may be the long-term average field moisture condition. For irrigated slopes, samples should be tested under saturated conditions. It should be noted that soaking a sample from both top and bottom can result in trapped air inside of the sample. It is often advantageous to soak samples only from the bottom until the surface of the sample suggests that soaking has achieved saturation by capillary rise.

3. Normal stresses need to be consistent with the problem being analyzed. For example, to analyze the surficial stability of a slope requires knowledge of the shear strength at normal stresses on the order of only 200 psf, which requires testing at very low confining stresses.

4. In order to obtain drained strength parameters, the speed of the direct shear test needs to be slow enough to ensure that pore pressures dissipate inside the sample. According to ASTM, the maximum speed is a function of t_{50}, which can be determined from consolidation theory using the Casagrande or Taylor methods (e.g., Holtz and Kovacs, 1981). Currently, ASTM D-3080 specifies that the time to failure is to be greater than $50 \cdot t_{50}$. Table 7.3 provides guidelines to assist in the specification of deformation rate for a direct shear test. These are based on correlations between coefficient of consolidation (c_v) and liquid limit from the U.S.

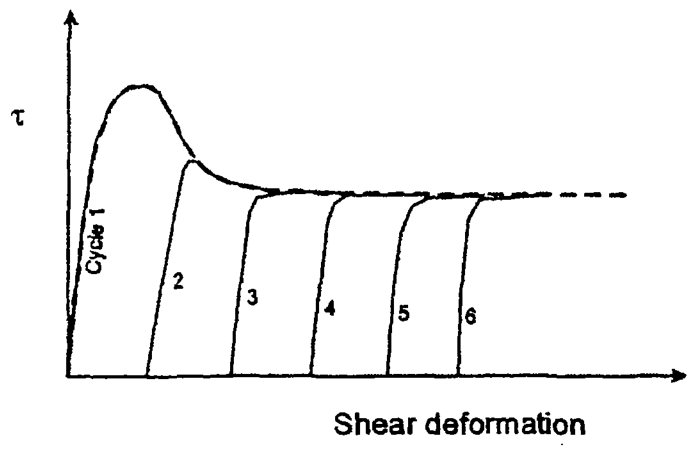


Figure 7.6. Schematic of Multiple-Cycle Direct Shear Test Results

Table 7.3. Reference Values of Time-to-Failure in Drained Direct Shear Test

Liquid Limit	Sample Condition	[illegible]*
40	Over Consolidated	0.25
	Normally Consolidated	1.5
	Remolded	6.0
60	Over Consolidated	1.5
	Normally Consolidated	4.0
	Remolded	15.0
80	Over Consolidated	4.0
	Normally Consolidated	10.0
	Remolded	30.0

* assuming 1.0 inch sample height and double drainage (multiply recommended times by 4.0 if drainage is only provided on one side of sample).

ii. Remolded Samples

Direct shear testing is often performed on remolded samples to evaluate either fully softened or residual strengths. Remolded samples should be prepared to approximate either the existing or the most critical anticipated conditions. The soil moisture content and density must both be carefully selected and controlled to achieve a sample that will yield a representative shear strength. The Committee recommends that samples that will be tested with a direct shear apparatus be remolded using the following guidelines. A bulk sample of the soil should be moisture conditioned to a moisture content at or above the optimum moisture content as unconsolidated undrained test (UU), in which drainage is not permitted during the application of confining pressure or shear.

As described in Table 7.2, CU or UU tests are recommended to determine the undrained shear strength of soft clay under static loading. In addition, CD tests are recommended together with the drained direct shear test to determine drained strengths of sand, very stiff clay, and clayey bedrock. The following additional discussion and guidelines are provided in this section with regard to the use of CU and CD tests for slope stability problems: CU tests should be performed in accordance with ASTM D4767-95, UU tests in accordance with ASTM D2850-95 (1999), and CD test in accordance with U.S. Army Corps of Engineers EM1110-2-1906.

In piston-type test equipment (in which the axial loads are measured outside the triaxial chamber), piston friction can have a significant effect on the indicated applied load, and measures should be taken to reduce the friction to tolerable limits.

The specimen cap and base should be constructed of lightweight material and should be of the same diameter as the test specimen in order to avoid entrapment of air at the contact faces.

The porous stones should be more pervious than the soil being tested to permit effective drainage.

Rubber membranes used to encase the specimen should provide reliable protection against leakage, yet offer minimum restraint to the specimen. Commercially available rubber membranes having thicknesses ranging from 0.0025 in. (for soft clay) to 0.01 in. (for sand or clay containing sharp particles) are generally satisfactory for sample diameters less than 2.5 inches. Rubber membranes about 0.01 in. or greater in thickness are suitable for larger specimens.

The sample specimen height-to-diameter ratio should be between 2 and 2.5. The largest particle size should be smaller than 1/6 the specimen diameter. If, after completion of a test, it is found based on visual observation that oversize particles are present, that information needs to be included in the report.

The average height of the specimen should be determined from at least four measurements, while the average diameter should be determined from measurements at the top, center, and bottom of the specimen as follows:

$$D_{avg} = \frac{D_{top} + 2D_{center} + D_{bottom}}{4} \tag{7.2}$$

For CU tests, failure can be defined either as the maximum deviator stress $(\sigma_1'-\sigma_3')_f$, the maximum obliquity, $(\sigma_1'/\sigma_3')_f$, or the stress at a certain specified axial strain. For dilative samples, a maximum deviator stress criteria may not be determined as its value will continue to increase with deformation. However, maximum obliquity value will reach a maximum and will not increase with the deformation. Therefore, for contractive samples, maximum obliquity criteria should be used for defining the failure. For dilative samples, either maximum deviator stress or maximum obliquity criteria will provide the same measure of shear strength; however, typically the maximum deviator stress is used in slope stability

(d) Laboratory Test Data Interpretation

The number of tests needed to estimate the shear strength of a geologic unit depends on factors such as local experience with the material, continuity of strata, spatial variability of properties, and consequences of erroneous estimation. When the number of tests performed is limited, appropriate conservatism should be used to select shear-strength values for slope stability analysis. The following general guidelines should be considered when testing shear-strength samples, and analyzing and applying their results.

If data are being developed to estimate the shear strength of a relatively homogeneous deposit (such as a uniform natural deposit or an artificial fill), a sufficient number of tests should be performed to characterize the variation that is likely to result from the natural process or construction techniques, considering the materials that are available to form the deposit. The results from a number of tests can be averaged, provided they are weighted in proportion to their abundance in the slope being analyzed. Alternatively, each layer could be entered into the slope stability analysis. If a wide variation in shear strength is observed across a large project site, it is necessary to verify that the strengths used for analysis of a specific slope are representative of the materials at that location.

If data are being developed to estimate the across-bedding strength of a layered deposit, the tests should be performed on representative material samples from each of the types of layers present. In many cases, an approximately weighted average value of shear strength can be used to model the across-bedding strength. Summary plots of shear strength data for each type of material in the layered deposit should be prepared. The test results from each type of material in a layered deposit should be averaged first. Then those averaged results should be weighted in proportion to their abundance and combined with similar results from other layers to obtain an overall weighted average. The engineer should be sure to consider the possibility that large-scale properties such as variations in cementation and fracturing could affect the strength of the deposit in a manner that might not be adequately represented by the laboratory test results.

The relation between the correction factor, μ, and the plasticity index, PI, has been obtained from field case history data and is shown in Figure 7.7.

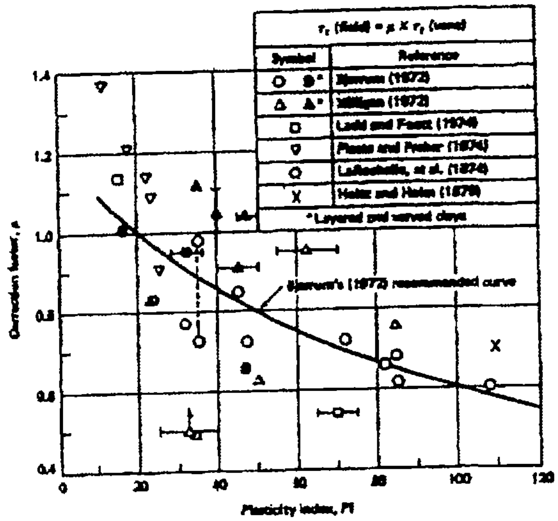


Fig. 7.7. Correlation Factor for the Field Vane Test as a Function of PI, Based on Embankment Failures (from Holtz and Kovacs, 1981)

7.3.5 Back Calculation of Strength Along a Failure Surface

Existing landslides offer the opportunity to estimate the average shear strength properties along the failure surface by mathematical methods. This procedure is generally referred to as back calculation or back analysis. The procedure requires the determination of the configuration of the landslide failure surface relative to the topography at the time of failure, variability in earth materials along the failure surface, the subsurface water level at the time of failure, external loading conditions, and the appropriate soil density. Once the above information is known, a mathematical analysis method appropriate to the slide configuration is chosen. The data described above are input into the analysis method, and an initial estimate is made of the shear strengths along the failure surface. The shear strength parameters are then adjusted and the analysis repeated until a factor of safety of 1.0 (FS=1.0) is obtained. This method provides different sets of cohesion, c, and friction angle, ϕ, which satisfy FS = 1.0. The engineer then selects an appropriate combination of c and ϕ. These strength parameters can then be utilized in the evaluation of alternate repair procedures. Skempton (1985) compared drained shear strengths obtained by careful testing of high-quality slip-surface samples with strengths determined by back calculation of the slides and found good correlation, indicating that the back-calculation method is valid for drained failures.

8 SOIL UNIT WEIGHT

The soil unit weight is required for the analysis of slope stability. The added weight due to the presence of subsurface water is accounted for by using the saturated unit weight of the soil. The use of the saturated unit weight (γ_{sat}) of the soil is conservative for most analyses. Although variations in moisture content (varying from dry to saturated) are possible, slope stability analyses should be performed using the saturated unit weight (unless specific justification for doing otherwise is provided by the consultant and approved by the regulatory reviewer). The estimation of saturated soil unit weight can be evaluated from the dry unit weight (γ_d) as follows,

$$\gamma_{sat} = \gamma_w + \gamma_d\left(\frac{G_s - 1}{G_s}\right) \tag{8.1}$$

where G_s = specific gravity of solids (typically 2.65-2.75),
γ_w = unit weight of water (62.4 pcf for fresh water)

In addition, relatively small (5 to 10 pcf) changes in density typically have little influence on the results of slope stability analyses. Saturated unit weights should be obtained from laboratory moisture-density tests on driven samples or conservative estimates from published sources such as the Slope Stability Reference Guide for National Forests in the United States (Hall et al., 1994).

mathematical models for slope stability calculations and the ability of the analyst to find the critical failure surface geometry.

Historically, the most commonly required factors of safety in southern California have been 1.5 for static long-term slope stability and 1.25 for static short-term (during construction) stability. Those factors of safety were established when computations were performed with slide-rules, when analysis methods solved at best two conditions of equilibrium, when only a few potential failure surfaces were analyzed, and when our understanding of factors influencing the shear strength of soil was less advanced. The level of uncertainty associated with those analyses justified the use of relatively high factors of safety.

The availability and speed of personal computers has allowed the development of more precise methods of analysis, which satisfy all three equations of static equilibrium, and the analysis of hundreds to thousands of potential failure surfaces. Therefore, the uncertainty related to computational methods and determination of the critical failure surface has been significantly reduced in recent years. Accurate representation of the soil shear strength for the problem being solved therefore introduces the highest level of uncertainty into current analyses. The Committee believes that the current static factors of safety remain applicable in cases where the shear strength of soil is determined by limited laboratory testing or by the use of the median values from standard correlations. However, we also believe that consideration should be given in the future to the use of lower factors of safety when uncertainty related to the shear strength is relatively small. For example, uncertainty is reduced when the shear strength is determined by back analysis of a well documented slope failure (in terms of geometry and water conditions). The Committee is not prepared to recommend specific lower safety factors at this time, but believes that this topic deserves consideration by controlling agencies.

The use of a factor of safety greater than 1.5 for static analyses is recommended if a slope in fractured or jointed cemented bedrock is analyzed using peak strength parameters derived from high quality samples of unfractured material. The use of a higher factor of safety is suggested in this instance because the joints and fractures introduce random planes of weakness into the deposit, which can significantly reduce the overall shear strength of the deposit. It is the Committee's judgment that factors of safety as high as 2.0 should be considered when a cemented material exhibits significant post-peak strength loss and contains a significant number of fractures in the location being analyzed. It should be noted that this higher factor of safety is not intended to be used when shear strengths are evaluated from de-aggregated samples.

analysis as a whole, which is most significantly influenced by the uncertainty in input parameters (such as soil strength). However, in situations where good quality sampling and testing have revealed consistent strength parameters or where regional knowledge dictates the use of specific parameters, the method of analysis can significantly affect the calculated FS.

The methods of Morgenstern and Price, Spencer, Sarma, Taylor, and Janbu's generalized procedure of slices satisfy all conditions of equilibrium and involve reasonable assumptions. Bishop's modified method does not satisfy all conditions of equilibrium, but is as accurate as methods that do, provided it is used only for circular surfaces. Duncan (1996) has found all of these methods to provide answers within 5% of each other.

Table 9.1. Characteristics of Commonly Used Methods of Limit Equilibrium Analysis (after Duncan, 1996)

Friction Circle Method (Taylor)	1937	Moment and force Equilibrium	Circular	Resultant tangent to friction circle
Ordinary Method of Slices (Fellenius)	1927	Moment Equilibrium of entire mass	Circular	Normal force on base of slice is W cos α and shear force is W sin α
Method of Slices (Fellenius)	1910	Force equilibrium of each slice		No interslice forces
Bishop's Modified Method	1955	Vertical equilibrium and overall moment equilibrium	Circular	Side forces are horizontal
Janbu's Simplified	1968	Force equilibrium	Any shape	Side forces are horizontal
Modified Swedish Method (U.S. Army Corps of Engineers Method)	1970	Force equilibrium	Any shape	Side force inclinations are equal to the parallel to the slope
Lowe and Karafiath's Method	1960	Vertical and horizontal force equilibrium	Any shape	Side force inclinations are average of slope surface and slip surface (varies from slice to slice)
Janbu's Generalized Method	1968	All conditions of equilibrium	Any shape	Assumes heights of side forces above the base vary from slice to slice
Spencer's Method	1967	All conditions of equilibrium	Any shape	Inclinations of side forces are the same for every slice; side force inclination is calculated in the process of the solution
Morgenstern and Price's Method	1965	All conditions of equilibrium	Any shape	Inclinations of side forces follow a prescribed pattern; side forces can vary from slice to slice
Sarma's Method	1973	All conditions of equilibrium	Any shape	Magnitudes of vertical side forces follow prescribed patterns

9.1e-f). In general, failure geometries with a near 90-degree angle in the lower portion of the slope should be avoided as these geometries will lead to unreasonable high normal stress concentrations near the right angle bend in the failure surface.

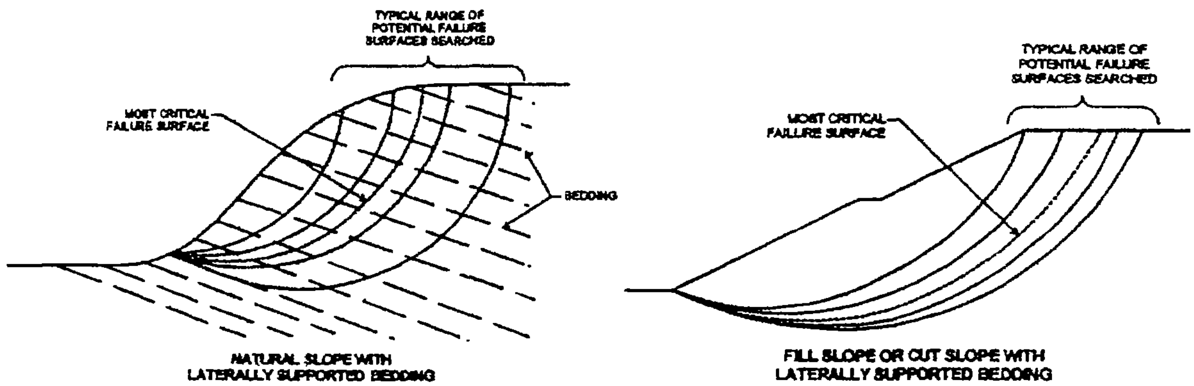


Figure 9.1a - b. Examples of Use of Circular Failure Surface Geometry

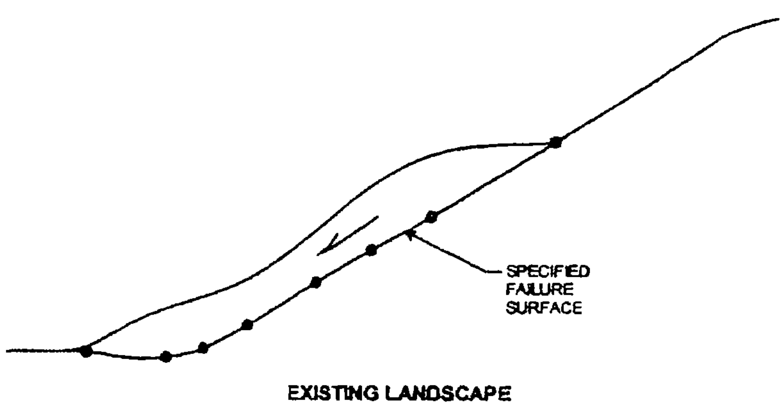
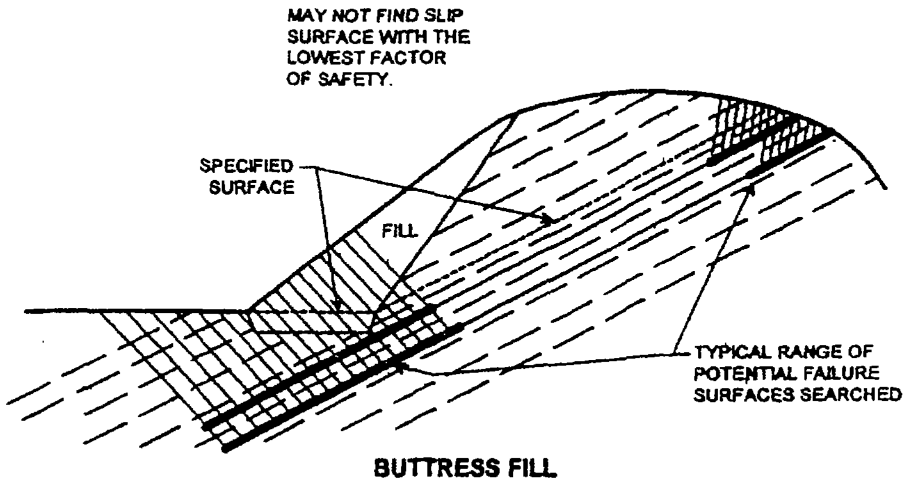


Figure 9.1c. Example of Use of Specified Failure Surface Geometry for Existing Landslide



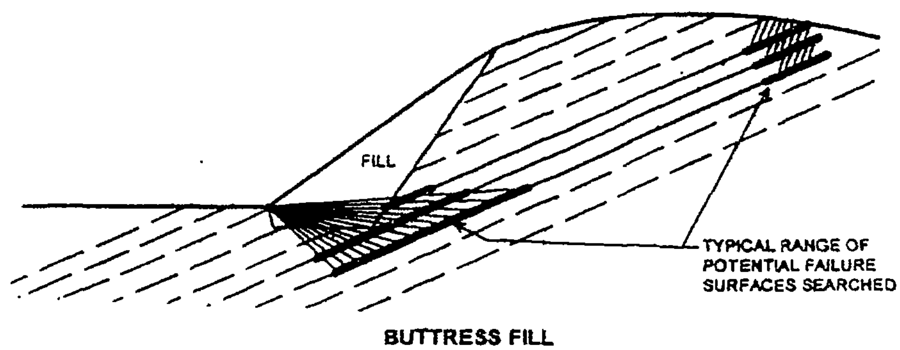


Figure 9.1f. Failure Surfaces Combining Along-Bedding and Cross-Bedding Failure - Buttress Fill (bottom diagram indicates correct geometries)

9.3.2 Tension Cracks

Tension cracks or vertical fractures may form at the crest of a slope or near the head of a landslide as failure is approached. Tension cracks should be considered in slope stability calculations, and in some cases those cracks should be assumed to have water in them. The tension crack lateral location along the slope should be the one that produces the lowest factor of safety, but in practice it may not be necessary to expend the iterative effort needed to determine the most critical position.

For most situations, the approximate depth of the tension crack can be estimated from the following equations. If the material through which the crack will form is generally homogeneous and isotropic, the depth of the tension crack may be estimated from:

local minimums are found. If the computer program works by generating a large number of circular surfaces in a random manner, the engineer needs to direct the computer to search enough surfaces so that adding more surfaces does not result in a significantly lower factor of safety.

If non-circular failure surfaces are to be used, geologic judgment and kinematics need to be considered. For example, if Spencer's method is used to generate a failure surface that has a nearly right-angle bend (see Figure 9.1e-f, upper frames) a kinematically unreasonable geometry results and the calculated factor of safety may be too high. That problem can be detected by checking for very high base-of-slice normal-stresses and shear resistances in narrow slices. Those high stresses and resistances result from the concentration of high side forces at the right-angle bend, which creates high base-of-slice normal-forces and unreasonably high shear-resistance. Spencer's analysis can yield factors of safety that are significantly higher than those produced by a simplified Janbu analysis when kinematically unreasonable surfaces are specified (dip-slope analyses with passive toe wedges can create that problem). The problem can often be resolved by searching for similar, but kinematically more reasonable surfaces, in nearly the same area (see Figure 9.1e-f, lower frames). If a computer program is used to generate a large number of non-circular randomly shaped surfaces, the engineer should carefully evaluate the results for convergence, since good geotechnical and geologic judgment can often result in finding more critical failure surfaces. To provide some guidance, several examples of procedures that can be used to search for the critical failure surface are shown on Figure 9.1

9.3.4 Search for Critical Failure Direction

Existing or potential failures that do not occur directly downslope require consideration of the critical direction of analysis (cross section direction that results in the lowest factor of safety). Landslides that do not occur directly downslope and slopes where the direction of bedding dip is oblique to the slope require that consideration be given to the direction of failure. In general, the analyst can start the search for a critical failure direction by evaluating cross sections that extend directly downslope and directly down the dip of the failure surface or bedding plane and then expanding that search to include intermediate directions, if such appear to be more critical.

9.4 GROUNDWATER CONDITIONS

Engineers performing computer-aided slope stability analyses should determine how the specific program they are using accounts for pore-water pressure and be sure that they specify it correctly. For example, in the computer program XSTABL, when a phreatic surface is used to describe pore-water pressures and that phreatic surface is above the ground, a water surcharge is applied to the ground surface. However, when a piezometric surface is used in XSTABL and that surface is above the ground, no water surcharge is applied to the ground surface. Also, when specifying a phreatic surface in XSTABL, the program assumes that equipotential lines are

- If realistic soil compressibility data are available, FE/FD methods can give general information about deformations at working-stress levels.

- FE/FD methods illustrate progressive failure up to and including overall shear failure. By contouring shear strains in the zones, it is possible to highlight failure surfaces.

For non-linear analyses using complex constitutive models that attempt to reproduce volumetric changes accurately in undrained or partially drained conditions, the incremental application of gravity can produce different results than would be obtained if gravity is applied all at once. However, if a simplified elasto-plastic model is used in FE/FD analyses, the factor of safety appears unaffected (Griffiths and Lane, 1999). Therefore, if the primary goal of the FE/FD analysis is to obtain a factor of safety, a simplified Mohr-Coulomb elasto-plastic model can be used with an instantaneous gravity "turn-on" procedure (Griffiths and Lane, 1999). To determine the factor of safety (FS) from FE/FD analyses, the "shear strength reduction technique" can be used (Matsui and San, 1992). In that procedure, the FS of a soil slope is defined as the number by which the original shear strength parameters must be divided in order to bring the slope to the point of failure (as indicated by numerical non-convergence or excessive displacement). The "factored" shear strength parameters c'_f and ϕ'_f are given by:

$$c'_f = c' / FS$$

$$\phi'_f = \arctan(\tan \phi' / FS)$$

The method would allow a different FS to be specified for the c' and tan ϕ' terms, but typically the same factor is applied to both terms. To find the slope's factor of safety, a systematic search is conducted to find the FS that initiates failure by solving the problem repeatedly using a sequence of user-specified FS values.

Modern FE/FD programs have enhanced graphical output capabilities that allow better understanding of the mechanisms of failure and simplify the output from reams of paper to useable graphs and plots of displacement. However, what remains is the concern that powerful tools such as the FE/FD method require considerable experience to properly evaluate the results.

The FE/FD method is a powerful tool which provides significant insight into the potential slope performance to the experienced user. A user should be thoroughly familiar with both the mathematical mode and the required input parameters before using this method.

slopes that are 2:1 in gradient or flatter should not, in the Committee's judgment, be required unless local experience indicates that slopes at that gradient commonly experience surficial instability.

terms of a median and standard deviation. Note that attenuation relations thus do not provide a specific value of the ground motion parameter. Therefore, even when a deterministic assessment of the causative earthquake is specified in terms of its magnitude and distance to the site, there is still a large range of potential ground motions that could occur as described by attenuation relations. Depending on the level of conservatism desired in deterministic analyses, typically either the median (50th percentile) or median-plus-one-standard-deviation (84th percentile) ground motion is used for design.

In the probabilistic approach, multiple potential earthquakes are considered. That is, all of the magnitudes and locations believed to be applicable to all of the presumed sources in an area are considered. Thus, the probabilistic approach does not consider just one scenario, but all of the presumed possible scenarios. Also considered are the rate of earthquake occurrence (how often each scenario earthquake occurs) and the probabilities of earthquake magnitudes, locations, and rupture dimensions. Moreover, the probabilistic approach considers all possible ground motions for each earthquake and their associated probabilities of occurring based on the ground motion attenuation relation.

The basic probabilistic approach yields a probabilistic description of how likely it is that different levels of ground motion will be exceeded at the site within a given time period, not merely how likely an earthquake is to occur. The inverse of the annual probability (i.e., the probability of exceedance for one year) is called the return period. Because probabilistic seismic hazard analyses sum the contribution of all possible earthquakes on all of the seismic sources presumed to impact a site, they do not result in a unique magnitude and distance that corresponds to the estimated acceleration value. Additional efforts are needed to extract the magnitude and distance most strongly contributing to the acceleration at a given hazard level. To estimate a magnitude and distance that can be paired with a given acceleration point (i.e., MHA and associated probability of exceedance), the hazard analysis for a given acceleration must be de-aggregated to develop the modal magnitude, $\bar{M}$, and modal distance, $\bar{r}$. Parameters $\bar{M}$ and $\bar{r}$ can be thought of as the magnitude and distance that contribute most strongly to the selected hazard level at the site. The process of de-aggregating the hazard to derive $\bar{M}$ and $\bar{r}$ is straightforward, but it must be understood that the de-aggregation is a function of hazard levels (i.e., different return periods). In addition, de-aggregation is sensitive to the ground motion parameter for which the hazard analyses are performed (i.e., different values of $\bar{M}$ and $\bar{r}$ could be obtained for MHA than for a long-period spectral acceleration).

There is a widespread misunderstanding of the relationship between deterministic and probabilistic analyses. Deterministic analyses are often (mistakenly) thought to provide "worst case" ground motions. That misunderstanding is a result of nebulous terminology that has been used in earthquake engineering. Terms such as "maximum credible earthquake" and "upper consistent with the UBC, ground motions should be obtained from a probabilistic seismic hazard analysis (PSHA).

Probabilistic seismic hazard analyses can be performed on a site-specific basis using available commercial computer codes. Alternatively, available CDMG maps can be used to estimate accelerations at different hazard levels. The CDMG maps can be useful provided the hazard level of interest is represented on the maps, there are not unusual soil conditions that could significantly affect ground motions (such as soft clay or peat), and the seismic source modeling used by CDMG remains appropriate (i.e., additional fault information compiled since publication of the CDMG maps has not rendered them obsolete). Estimation of peak accelerations using the state maps or site-specific analyses are discussed below.

10.2.1 State Maps

Ground motion maps are being created for each area affected by the California Seismic Hazards Mapping Act as a by-product of the delineation of Seismic Hazards Zones by the Department of Conservation. They form the basis of earthquake shaking opportunity in the regional assessment of liquefaction and seismically-induced landslides for zonation purposes. The maps are generated at a scale of about 1:150,000, using the MapInfo® street grid as the base. The maps are produced using a data-point spacing of about 5 kilometers (0.05 degrees), which is the spacing that was used to prepare the small-scale state ground-motion map used for the Building Code (Petersen et al., 1996; Frankel, 1996; Petersen et al., 1999).

Ground motions shown on the maps are expressed as maximum horizontal accelerations (MHA) having a 10-percent probability of being exceeded in a 50-year period (corresponding to a 475-year return period) in keeping with the UBC-level of hazard. Separate maps are prepared of expected MHA for three types of surficial geology (hard rock, soft rock, and alluvium), based on averaged ground motions from three different attenuation relations. When using those maps, it should be kept in mind that each assumes that the specific soil condition is present throughout the entire map area. Use of a MHA value from a particular soil-condition map at a given location is justified by the soil class determined from the site-investigation borings.

The set also includes a map of modal magnitude and distance pairs (i.e., $\overline{M}$ and $\overline{r}$) calculated at the same grid spacing as MHA. Those values represent the de-aggregated 475-year hazard level, and are available for the ground motion parameter of MHA for an alluvial site condition (the parameters are not sensitive to site condition, and hence the values on the maps can also be used for rock and soft rock site conditions). Because of the discrete nature of de-aggregated hazard, the user is cautioned not to interpolate modal parameters to the project site location when using

10.2.3 Site-Specific Deterministic Analyses

Deterministic analyses can be used to evaluate the seismic demand that would be placed on a site if a specific earthquake were to occur. If deterministic seismic hazard analyses are to be used to develop ground motion estimates, the following should be clearly documented in the project report: definition of the scenario earthquake, attenuation relationship used to evaluate ground motions for the scenario earthquake, and the percentile ground motion (e.g., 50th, 84th, etc.) that was selected. The engineer may wish to consult with the reviewing agency in developing these criteria for deterministic analyses. For non-critical structures, many engineers have used median ground motions from attenuation relations based on characteristic magnitudes associated with nearby faults; whereas for critical structures, 84th percentile ground motions have sometimes been used. In a region where an individual fault dominates the seismic hazard, the level of uncertainty to be used in prescriptive deterministic analyses can be estimated by performing probabilistic analyses and comparing the results with deterministic analyses at different uncertainty levels.

10.3 OTHER GROUND MOTION PARAMETERS

As noted at the beginning of this chapter, three ground motion parameters are needed for the evaluation of seismic slope stability – MHA, duration of strong shaking ($D_{5\text{-}95}$), and mean period (T_m). Of those, only MHA maps are currently available from CDMG. The focus of this section, therefore, is the estimation of $D_{5\text{-}95}$ and T_m for seismic slope displacement calculations.

The parameters $D_{5\text{-}95}$ and T_m are functions of magnitude (M), distance (r), and site condition (S=0 for rock, S=1 for soil). For a given M, r, and S, regression equations are available that provide a log-normal distribution of the $D_{5\text{-}95}$ and T_m parameters, not a single value. For use with the seismic slope displacement methodology discussed in Section 11.2, median values of $D_{5\text{-}95}$ and T_m can be used. Those values should be evaluated for the $\overline{M}$, $\bar{r}$ magnitude-distance pair (where $\overline{M}$ and $\bar{r}$ represent the 475-year hazard level for MHA). At their discretion, consultants may also wish to consider additional scenario earthquakes with larger magnitudes that might occur on major faults near the site. Once a magnitude-distance pair has been selected, median values of $D_{5\text{-}95}$ and T_m can be calculated as follows:

Duration (Abrahamson and Silva, 1996)

Median values of $D_{5\text{-}95}$ on rock can be estimated as follows. For r >10 km,

11 SEISMIC SLOPE STABILITY ANALYSIS

11.1 INTRODUCTION

11.1.1 Background

Recent practice for analysis of seismic slope performance has been to use a pseudo-static representation of seismic loading in a conventional limit-equilibrium analysis, or to perform a displacement analysis based on the analogy of a rigid block on an inclined plane (i.e., Newmark-type displacement analysis; Newmark, 1965).

There are two elements associated with a pseudo-static slope stability analysis procedure. First, a horizontal destabilizing seismic coefficient (k) must be specified, which represents the fraction of the weight of the slide mass that acts horizontally through the centroid of the mass. Second, a minimum acceptable factor of safety must be specified for the slope with the pseudo-static seismic force applied to it. In southern California, the most commonly used pseudo-static procedure is one adopted by Los Angeles County, and is modified from the recommendations of Seed (1979). The Seed procedure calls for $k = 0.15$ and $FS \geq 1.15$, and was calibrated from Makdisi and Seed (1978) displacement analyses so as to produce slope deformations of one meter during magnitude 8.25 earthquakes. LA County has modified this procedure to have $k = 0.15$ and $FS \geq 1.10$. Pseudo-static methods are recommended herein for the purpose of a screen analysis for slopes within hazard zones. However, the recommended procedures for screen analyses are modified from the Seed criterion to more properly account for the effects of seismicity on slope deformation hazard, and to recognize the relatively small deformation tolerance of typical hillside construction. These procedures are described in Section 11.2.

Newmark-type displacement analyses can be performed with two general methods. The first involves formal numerical integration of time histories of shaking within a slide mass according to the procedure described by Franklin and Chang (1977). The second method makes use of correlations between calculated Newmark displacements, selected ground motion parameters, and the ratio of seismic load resistance to peak demand (k_y/k_{max}, see definitions below). Several such correlations are available, including Makdisi and Seed (1978) and Bray and Rathje (1998).

T_m = mean period of input rock motion (sec)

T_s = fundamental period of equivalent 1-D slide mass at small strains (sec)

u = calculated slope displacement (in cm)

11.2 SCREENING ANALYSIS

11.2.1 Background

Seismic Hazard Zone maps published by the CDMG include Landslide Hazard Zones. Analyses of the type described in this chapter are required for sites located within those zones. The purpose of these analyses is to determine if the site has a significant seismic slope deformation potential. The mere fact that a site is within a Landslide Hazard Zone does not mean that there necessarily is a significant landslide potential at the site, only that a study should be performed to determine the potential.

The SP 117 Guidelines state that an investigation of the potential seismic hazards at a site can be performed in two steps: (1) a screening investigation and (2) a quantitative evaluation. The purpose of the screening investigation for sites within zones of required study is to filter out sites that have no potential or low potential for landslide development.

The screening criteria described in Sections 11.2.2 to 11.2.3 below may be applied to determine if further quantitative evaluation of landslide hazard potential is required. If the screening investigation clearly demonstrates the absence of seismically induced landslide hazards at a project site and the lead agency technical reviewer concurs, the screening investigation will satisfy the site investigation report requirement for seismic landslide hazards. If not, a more thorough quantitative evaluation will be required to assess the seismic landslide hazard, as described in Section 11.3.

11.2.2 Development of Screening Analysis Procedure

The screening analysis procedure recommended herein is based on a pseudo-static representation of seismic slope stability. The procedure is implemented by entering a horizontal seismic coefficient (k) into a conventional slope stability calculation. The seismic coefficient represents the fraction of the weight of the sliding mass that is applied as an equivalent horizontal force acting through the centroid of the mass. If the factor of safety is greater than one (FS > 1), the site passes the screen, and the site fails if FS < 1.

The seismic coefficient to be used in the analyses is taken as,

$$k_{eq} = f_{eq} \times (MHA_r / g) \qquad (11.1)$$

3. Factor k_{max} is related to $MHA_r \times NRF/g$, where NRF is a factor that accounts for the nonlinear response of the materials above the slide plane. Parameter $D_{5\text{-}95}$ is a function of magnitude and distance, as discussed in Section 10.3.

Based on the above, calculations were performed to evaluate for various combinations of MHA_r, magnitude, and distance, the f_{eq} values that cause the probability that seismic slope displacement would exceed 5 cm or 15 cm to be 50%. The Committee chose to use a 50% probability level because we believed probabilities departing significantly from 50% could significantly bias the effective return period from the standard 475-year hazard level. Additional details on this calculation are provided in Appendix A. The results of the calculations are shown in Figures 11.1(a) and 11.1(b) for the 5 cm and 15 cm threshold displacements, respectively.

The equation of the curves in Figure 11.1 is as follows:

$$f_{eq} = \frac{NRF}{3.477} \times \left[1.87 - \log_{10}\left(\frac{u}{(MHA_r / g) \times NRF \times D_{5\text{-}95}} \right) \right] \tag{11.2}$$

where u is in units of cm, $D_{5\text{-}95}$ = median duration (in seconds) from Abrahamson and Silva (1996) relationship (defined in Eq. 10.1) and NRF is defined by the relationship tabulated subsequently in Figure 11.2, which can be approximated by:

$$NRF \approx 0.6225 + 0.9196 \times Exp\left(\frac{-MHA_r / g}{0.4449} \right) \tag{11.3}$$

for $0.1 < MHA_r/g < 0.8$.

11.2.3 Screening Criteria

In summary, the following procedure is recommended for performing screening analyses for seismic slope stability:

1. Set up an analytical model for the slope as would normally be done for a static application, but with soil strengths that are appropriate for dynamic loading conditions. As noted in Chapter 7, this may require that different drainage conditions be considered than in the static case, and also requires consideration of rate effects and cyclic degradation on soil strength.

2. Use the procedures in Section 10.2 to estimate the maximum horizontal acceleration at the location of the site for a rock site condition (MHA_r). Parameter MHA_r should generally be evaluated using probabilistic seismic hazard analysis for a 475-year return period. Identify the mode magnitude ($\overline{M}$) and mode distance ($\bar{r}$) from de-aggregation of that hazard level.

3. Evaluate the site seismic coefficient using the procedures described in Section 11.2.2 with a value of threshold displacement that is considered acceptable by the local regulatory agency.

4. Perform a pseudo-static calculation of slope stability using the seismic coefficient from (3), and find the minimum factor of safety. Note that the critical failure surface will generally be shallower than the critical surface without a seismic coefficient.

5. Denote the factor of safety from (4) as FS. If FS > 1, the site passes the screen. However, for critical projects, consultants may want to perform additional checks for specific, large seismic sources in the local area, calculating M and r for each source deterministically. For each source considered, one would evaluate MHA_r and f_{eq} deterministically, and then check

MHA-*M*-*r* parameters can be translated into a more useful representation of demand for slope stability analysis.

The seismic loading for a potential sliding mass can be represented by the horizontal equivalent acceleration, HEA. HEA/*g* represents the ratio of the time-dependant horizontal inertia force applied to a slide mass during an earthquake to the weight of the mass. For a horizontal slide plane and horizontal ground surface, HEA can be calculated as:

$$HEA(t) = \left(\frac{\tau_h(t)}{\sigma_v} \right) g \tag{11.4}$$

where t indicates that there is time variation, τ_h is the horizontal shear stress at the depth of the sliding surface calculated by a one-dimensional seismic site response analysis program (e.g., SHAKE91, Idriss and Sun, 1992; D-MOD, Matasovic, 1993), and σ_v is the total vertical stress at the depth of the sliding surface. For more complex geometries (i.e., not one-dimensional), a rigorous analysis of HEA requires the use of two-dimensional finite element analyses (e.g., QUAD4M; Hudson et al., 1994). Rathje and Bray (1999a) have found that 1-D analyses generally provide a conservative estimate of HEA(t) for deep sliding surfaces and a slightly unconservative estimate for shallow surfaces near slope crests. MHEA is the maximum horizontal equivalent acceleration over the duration of earthquake shaking. For slope displacement analyses, seismic demand is typically represented by HEA time histories or MHEA coupled with duration $D_{5\text{-}95}$.

The seismic demand in a slide mass can be relatively rigorously evaluated from two dimensional finite element dynamic response analyses using a program such as QUAD4M (Hudson et al., 1994). Those analyses enable the evaluation of HEA time histories that are customized to the specific geometry and soil condition at the subject site. The analyses should be performed using sets of at least 5-10 time histories as input. Those time history sets should be appropriate for the magnitude and site-source distance that control the site hazard. Fewer time histories (3-4) can be used if they are scaled to match the constant hazard spectrum for the site (established from a site-specific probabilistic seismic hazard analysis) across the period range of interest (e.g., Richardson et al., 1995; Kavazanjian et al., 1997). Further discussion on time histories for slope displacement analyses is provided in Section 11.3.3.

A second procedure represents the amplitude of seismic demand with MHEA. The procedure was developed by Bray et al. (1998) from statistical analysis of many wave propagation results in equivalent one-dimensional slide masses. The procedure normalizes MHEA in the slide mass by the product of MHA_r and a nonlinear response factor (NRF). Parameter NRF accounts for nonlinear ground response effects as vertically propagating shear waves propagate upwards

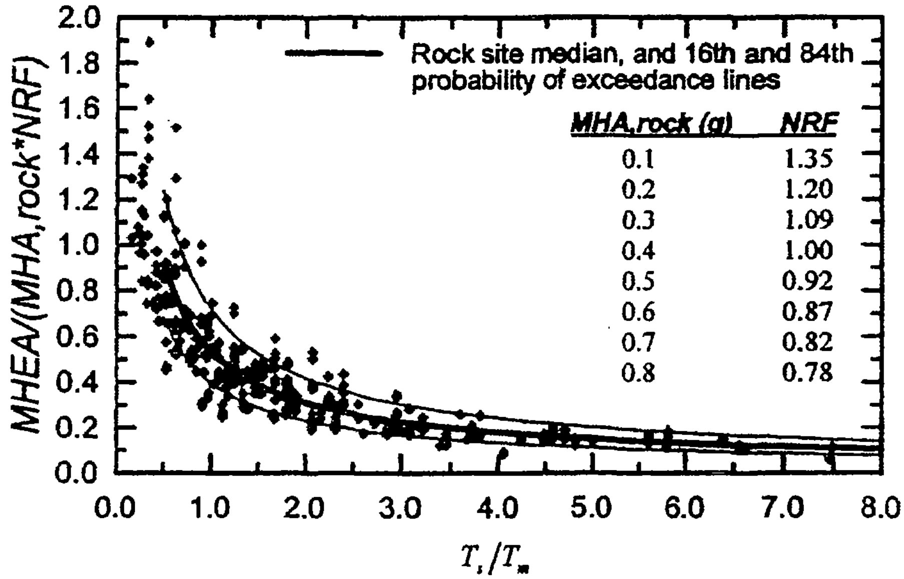


Figure 11.2. Normalized MHEA for Deep-Seated Slide Surface Vs. Normalized Fundamental Period of Slide Mass (after Bray et al., 1998).

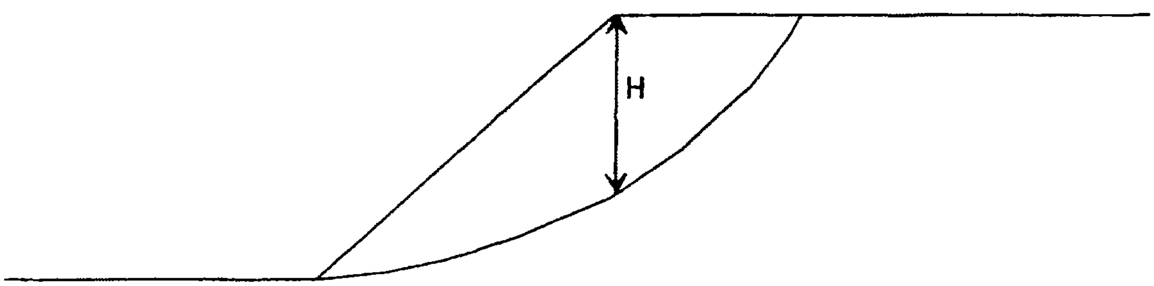


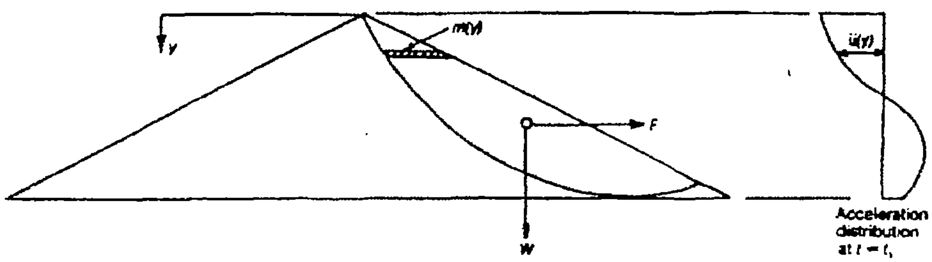
Figure 11.3. Definition of Height of Slide Mass for Use in Equation 11.5

11.3.3 Estimation of Seismic Slope Displacements

Two possible quantifications of demand for slope stability calculations were described in Section 11.3.2:

- Use of a simplifying assumption to evaluate MHEA = $k_{max} \cdot g$.
- Use of dynamic analysis to define time histories of horizontal equivalent acceleration, HEA(t).

The second method for estimating slope displacement utilizes the recommendations of Makdisi and Seed (1978) for relating k_y/k_{max} to displacement u. Parameter k_{max} for application in the Makdisi and Seed procedure is not evaluated using the methods described in Section 11.2.2. Rather, the MHA at the crest of a triangular embankment section is evaluated, and k_{max} is estimated using Figure 11.5. The Committee is not aware of simplified procedures for evaluating the crest MHA for typical fill slope geometries, which are not triangular in cross-section. Such an evaluation would need to consider ground response effects through the slide mass and topographic effects. A consultant using the Makdisi and Seed approach should reach an agreement with the cognizant public official regarding an appropriate procedure for evaluating this crest acceleration, as well as a procedure for evaluating k_{max} from crest acceleration for non-triangular slope geometries.



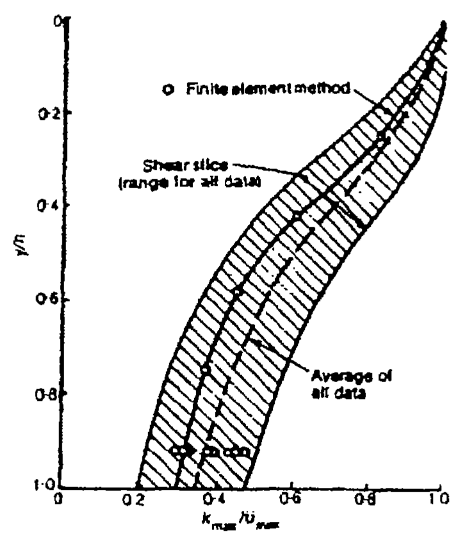


Fig. 11.5. Variation of k_{max} with Depth in Triangular-Shaped Embankment Section (Makdisi and Seed, 1978). Parameter $\ddot{u}_{max}$ Denotes Peak Acceleration at Embankment Crest.

As noted previously in Section 11.3.2, Newmark displacement analyses should generally be performed using HEA time histories, because such motions account for the effects of ground motion amplification and incoherence through the slide mass. However, there are a limited number of cases where Newmark analyses can be performed using as-recorded accelerograms as estimates of HEA time histories. As recommended by Rathje and Bray (1999b), this practice is acceptable for very short period slide masses having $T_s/T_m < 0.2$.

Finally, it should be noted that the identification of the most critical slip surface for seismic slope displacement analysis depends not only on the slope/material properties (as is the case under static conditions), but also on the variation of shaking in the slope. What is desired is the k_y/k_{max} combination that yields the largest slope displacement. In many cases, this will be the critical surface identified from the calculations described in Section 11.3.1. Shallower surfaces should be checked, however, because while they will have higher k_y values, they may also have larger k_{max} values, which could lead to larger displacements. The Committee considers the use of shallower surfaces to be unnecessary if MHEA/(MHA$_r$ $\times$ NRF) = 1.0. However, if MHEA/(MHA$_r$ $\times$ NRF) is less than 1.0 (see Figure 11.2), at a minimum, one additional surface should be considered and it is the deepest surface that produces MHEA/(MHA$_r$ $\times$ NRF) = 1.0 (note that this will be shallower than the surface having the lowest k_y).

11.3.4 Tolerable Newmark Displacements

The final step in the analysis is to decide if the calculated displacement is acceptable. Ideally, allowable displacements for analyses would be established from a database in which observed slope displacements from earthquakes are correlated to measures of damage in structures associated with the slope displacements. Unfortunately, however, such data do not exist in sufficient quantity to be useful, and hence there is no rational basis for selecting allowable displacements. Accordingly, allowable displacement levels are established from engineering judgment. The judgment of the majority of the Committee is that if the critical slip surface from slope stability analyses daylights within a structure that is likely to be occupied by people during an earthquake, the median displacements (u) should be maintained at less than 5 cm. A minority of the Committee feels that those displacements through occupied structures should be maintained at less than 15 cm. Neither of these values (5 or 15 cm) is necessarily the "correct" value, because they are judgment-based. Individual agencies may wish to select their own allowable displacement values based on their experience and judgment. No matter which allowable displacement values are selected, the procedures described in the preceding sections can be readily applied with those threshold displacements.

The scope of this Committee's activities, and the Seismic Hazards Mapping Act, does not extend beyond inhabited structures. However, owners, engineers, or cognizant public officials may, at

12 SLOPE STABILITY HAZARD MITIGATION

Slopes that possess factors of safety less than required by the governing agency, or with unacceptably large seismic slope displacements, require avoidance or mitigation to improve their stability. Even if a slope is found from analyses to be stable, it might require protection in order to avoid degradation of shear strengths from weathering, to remain stable under future increased loading conditions, to prevent toe erosion, or to remain stable under future, potentially higher groundwater conditions than assumed in the analyses. Protection for adjacent pad areas may also be required to minimize hazard from erosion and falling debris.

The most common methods of mitigation are (1) hazard avoidance, (2) grading to improve slope stability, (3) reinforcement of the slope or improvement of the soil within the slope, and (4) reinforcement of the structure built on the slope to tolerate the anticipated displacement. Avoidance involves placing a proposed improvement a sufficient distance from an unstable slope. Grading methods commonly employed to improve slope stability include partial or complete replacement of unstable soil. Slopes can be strengthened with soil reinforcement, retaining walls, deep foundations, geosynthetics, and/or soil nails/tiebacks can be used alone or in conjunction with grading to improve slope stability. Soil can be improved with cement or lime stabilization. Structures built on slopes also can be sufficiently reinforced to reduce damage to a tolerable amount. In addition, structures can be effectively isolated from ground deformations through the use of piles or compaction grouting.

The mitigation measures chosen for a given slope must be analyzed recognizing that different mitigation measures require analyses for different modes of failure. Some methods (for example, slope reinforcement) require consideration of strain compatibility and soil/structure and/or soil material interaction issues. The following sections describe both stabilization and mitigation measures, and the potential modes of failure that should be analyzed.

Creation of a temporary backcut is usually required when performing partial or total removal and replacement. The backcut must be analyzed and designed to have a sufficient static factor of safety during construction, typically 1.25, to allow the safe construction of the permanent slope

12.2.3 Stability Fills

A stability fill is used where a slope has an adequate factor of safety for gross stability, but an insufficient factor of safety for surficial stability or where the materials exposed at the slope surface are prone to erosion, sloughing, rock falls, or other surficial conditions that require remediation. Stability fills are relatively narrow, typically about 10 to 15 feet wide. Soil placed in the stability fill should be compacted to at least 90 percent of the maximum density as determined by ASTM D1557, unless a different degree of compaction is recommended by a Geotechnical Engineer and approved by the governing agency. Water content also should be controlled during compaction, because fills compacted to water contents wetter than the line of optimums have been shown to perform significantly better than fills compacted to lower water contents in both static and seismic conditions (Lawton et al., 1989; Whang, 2001). A higher percent relative compaction may be required for steeper slopes and coarse-grained soil types. That can be facilitated by overbuilding the slopes and trimming them back to the compacted core (which is preferable to rolling the surface of the slope).

Stability fills should be keyed into firm underlying soil or competent bedrock. The key should be at least as wide as the stability fill and should extend at least 3 feet below the toe of the slope. Both the gross and surficial stability of the stability fill should meet the minimum stability requirements set by the governing agency. The gross or deep-seated stability should be analyzed along failure surfaces extending through the toe of the slope and beneath the keyway. Combinations of circular and non-circular failure surfaces should be used as applicable.

12.2.4 Buttress Fills

A buttress fill provides the features of a stability fill, but is used where a slope does not have a sufficient factor of safety for gross or deep-seated stability and additional resistive forces are required. For example, buttress fills can be used to support upslope landslides or slopes in sedimentary rock where the bedding is adversely dipping out of the slope.

The base of a buttress fill is typically wide, usually ranging from about one third to almost the full height of the slope being buttressed. The actual width of the buttress must be determined by slope stability analysis. Soil placed in the buttress fill should be compacted to a minimum of 90 percent of the maximum density as determined by ASTM D1557, unless a different degree of compaction is recommended by a Geotechnical Engineer or required by the governing agency. Water content also should be controlled, as discussed in Section 12.2.3. Buttress fills should be

Chimney drains can be provided every 25 to 50 linear feet at the interface of the stabilization fill and natural ground to enhance the backdrain system performances. The purpose of a chimney drain is to collect subsurface water from multiple bedding planes. The use of chimney drains is particularly important for buttress fills that will support bedded rock with considerably different permeability between layers. Conventional near-horizontal subdrains often will not collect water from the permeable layers because they do not intersect or cross the permeable beds. The chimney drains should be continuous between lateral backdrains and should be a minimum of 2 feet in width. Chimney drains may be created by stacking gravel-filled burlap (not woven plastic) bags, placement of a continuous gravel column surrounded by non-woven filter fabric, or placement of a drainage composite. Drain locations and outlet pipes should be surveyed in the field at the time of installation.

12.3 ENGINEERED STABILIZATION DEVICES AND SOIL IMPROVEMENT

A grading solution to a slope stability problem is not always feasible due to physical constraints such as property-line location, location of existing structures, the presence of steep slopes, and/or the presence of very low-strength soil. In such cases, it may be feasible to mechanically stabilize the slide mass or to improve the soil with admixture stabilization. The resulting slope should be analyzed to meet the same requirements as other slopes.

Mechanical stabilization of slopes can be accomplished using retaining walls, deep foundations (i.e., piles or drilled shafts), soil reinforcement with geosynthetics, tieback anchors, and soil nails. Common admixture stabilization measures include cement and lime treatment as well as Geofibers™.

12.3.1 Deep Foundations

The factor of safety of a slope can be increased by installing soldier piles/drilled shafts through the unstable soil into competent underlying materials. The piles/drilled shafts are sized and spaced so as to provide the required additional resisting force to achieve adequate slope stability. The piles/drilled shafts typically provide resistance through the bending capacity of the shaft anchored by passive resistance in stable earth materials underlying the slide mass.

The load applied to the deep foundation from material above the potential failure surface is commonly represented using a uniform or equivalent fluid pressure (triangular) distribution. Resistance to failure is provided by passive earth pressure within the "stable earth materials." In this context, stable earth materials are defined as those materials located beneath the potential failure surface having a static FS $\geq$ 1.5 and along which the anticipated seismic displacement is less than 5 cm or 15 cm (with the effects of the deep foundations and any other stabilization devices such as tieback anchors excluded in the analysis). In general, no resistance should be deflections of the deep foundations are of concern, deflections can be calculated based on soil properties evaluated using unfactored soil strengths. Soldier piles/drilled shafts used to stabilize the slope and provide support for a structure should be tied in two lateral directions such that the potential for lateral separation is minimized.

12.3.2 Tieback Anchors

The loads on the soldier piles/drilled shafts are, in some cases, higher than these elements can support in cantilever action alone. Tieback anchors can be incorporated in those cases to provide additional resistance. Tieback anchors also can be used without soldier piles/drilled shafts by anchoring them against a wall or reinforced face element. Tieback anchors consist of steel rods or cables that are installed in a drilled, angled holes. The rods/cables are grouted in place within the reaction zone and extend through a frictionless sleeve in the unstable mass. The anchors are post-tensioned after the grout reaches its design strength. Anchors are often tested to a load that is higher than the design load. The anchors must be long enough to extend into stable earth materials as defined in Section 12.3.1.

Temporary anchors generally do not need to be protected from corrosion. Permanent anchors should be protected from corrosion for the design life of the project. A reference for the design of ground anchors is Sabatini et al. (1999).

12.3.3 Soil Nails

Soil nailing involves earth reinforcement by placing and grouting reinforcing rods in holes drilled in the ground. The reinforcing rods are not pre-stressed or post-tensioned. Soil nailing should not be used in relatively fines-free gravel and sandy soil. A reference for the design of soil nails is Bryne et al. (1996). Soil nailing for permanent slope stabilization has been widely used by CalTrans and FHWA in Public Works projects. The application of this technique for general use is currently being studied by a special committee in southern California.

12.3.4 Retaining Structures

A retaining wall can be constructed through an unstable slope to provide additional resistance and raise the factor of safety for material behind the wall to an acceptable level. Retaining structures should be founded in stable earth materials as defined in Section 12.3.1. The retaining structure should be evaluated for possible sliding, overturning, and bearing failures using standard techniques. Failure surfaces that extend below the wall foundation and above the top of the wall also should be analyzed. Analysis of walls that support bedded rock dipping toward the wall is facilitated by use of a computer program that also allows the use of anisotropic strength parameters. Consideration must be given to whether material in front of the wall that is assumed

The effectiveness of dewatering drains or wells needs to be checked periodically by measuring the water levels in the slope. Drains and wells, whether pumped or static, require periodic maintenance to assure that the casing does not become clogged by fines or precipitates and that the pump is functioning. The effectiveness of subsurface drainage control features is dependent on proper maintenance of the drains and/or wells. Where proper maintenance of the wells/drains cannot be guaranteed for the time period during which the stability of the slope is to be maintained, a dewatering system should not be relied upon to achieve the required factor of safety.

"Passive" dewatering with subdrains was discussed previously in section 12.2.6.

12.5 CONTAINMENT

Loose materials, such as colluvium, slopewash, slide debris, and broken rock, on the slope that could pose a hazard can be collected by a containment structure capable of holding the volume of material that is expected to fail and reach the containment device over a given period of time. The containment structure type, size, and configuration will depend on the anticipated volume to be retained and the configuration of the site. Debris basins, graded berms, graded ditches, debris walls, and slough walls can be used. In some cases, debris fences may be permitted, although those structures often fail upon high-velocity impact.

The expected volume of debris should be estimated by the geologist and engineer. Debris walls and slough walls should be designed for a lateral equivalent pressure of at least 125 pounds per cubic foot where impact loading is anticipated and at least 90 pounds per cubic foot elsewhere unless otherwise allowed by the regulatory agency and/or justified by the consultant. The height of the catchment devices may be governed by the expected debris volume of the expected bounce height of a rolling rock. The CRSP program (Jones, et al., 2000) can be used to estimate rolling rock trajectories.

Access should be provided to debris containment devices for maintenance. The type of access required is dependent on the anticipated volume of debris requiring removal. Wheelbarrow access will be sufficient in some cases, whereas heavy equipment access may be required in other areas.

12.6 DEFLECTION

Walls or berms that are constructed at an angle to the expected path of a debris flow can be used to deflect and transport debris around a structure. The channel gradient behind those walls or berms must be sufficient to cause the debris to flow rather than collect. Required channel gradients may range from 10 to 40 percent depending on the expected viscosity of the debris and

13 CONCLUDING REMARKS

This document has presented a broad overview of landslide hazard analysis, evaluation, and mitigation techniques. The Implementation Committee acknowledges that the state of the art in slope stability evaluation continues to evolve and advance and that new methodologies in geotechnical engineering, soil/shear strength testing, slope-stability analysis, and mitigation will develop.

Many of the issues germane to this topic, such as strength evaluation and the treatment of uncertainties, were the subjects of extended debate by the Committee. Typically at issue was the pervasive use in current practice of antiquated technologies that provide misleading, or at best highly uncertain, outcomes. All too often, the Committee was compelled to adopt language encouraging (or at least allowing) the use of such technologies when more robust (but invariably more expensive) alternatives exist. One important example of this is the use of direct shear strength testing of samples from Modified California samplers. Another is the continued use of a static FS=1.5 regardless of the level of subsurface characterization and project importance. Technologies currently exist, and continue ~~to be developed,~~ that allow geotechnical engineering practice to move beyond gross conservatism and almost ~~purely judgment-based~~ design. What is needed is clear recognition by consultants, regulators, and owners of the economic and societal benefits of proper geotechnical work. If the provisions in this document are adopted in practice, it will represent a small step in the right direction, but all parties involved must remain diligent in trying to advance the all too often tradition-bound profession we share.

The implementation of SP 117 represents an important step in furthering seismic safety in the State of California. Proper analysis of both the static and seismic stability of slopes is critical to the safety and well being of Californians as development continues to expand into hillside areas. It is the hope of the Implementation Committee that this document will make a contribution toward that goal and provide useful information and guidance to owners, developers, engineers, and regulators in the understanding and solution of the slope stability and landslide hazards that exist in California and in other tectonically active regions.

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ABSTRACT

Site-specific seismic slope stability analyses are required in California by the 1990 California Seismic Hazards Mapping Act for sites located within mapped hazard zones and scheduled for development with more than four single-family dwellings. A screen analysis is performed to distinguish sites for which only small ground deformations are likely from sites for which larger, more damaging landslide movements could occur. No additional analyses are required for sites that pass the screen, whereas relatively detailed analyses are required for sites that fail the screen. We present a screen analysis procedure that is based on a calibrated pseudo-static representation of seismic slope stability. The novel feature of the present screen procedure is that it accounts not only for the effects of ground motion amplitude on slope displacement, but also accounts for duration effects indirectly via the site seismicity. This formulation enables a more site-specific screen analysis than previous formulations that made *a priori* assumptions of seismicity/duration.

reduces the pseudo-static factor of safety (FS) for a given slope to unity, and is referred to as the yield acceleration, k_y. The second is the peak value of spatially averaged horizontal acceleration (normalized by g) across the slide mass, and is denoted k_{max}.

Perhaps the most widely used screen analysis procedure is that developed by Seed (1979) for application to earth dams. The procedure calls for k = 0.1 or 0.15 to be applied for M = 6.5 and 8.25 earthquakes, respectively. The screen is passed if the factor of safety, FS, exceeds 1.15. A slightly modified version of that procedure, in which k = 0.15 and FS ≥ 1.1 regardless of local seismicity, was adopted in 1978 by Los Angeles County for application to hillside residential construction. Seed (1979) recommended that his procedure only be applied for cases where the earth materials do not undergo significant strength loss upon cyclic loading (i.e., strength loss < 15%) and where several feet of crest displacement was deemed "acceptable performance," as is the case for many earth dams (e.g., 0.9 m displacement for M = 8.25 and crest acceleration = 0.75g).

An important feature of the Seed (1979) procedure is its calibration to a particular slope performance level, which is represented by the displacement of a rigid block on an inclined plane (i.e., a "Newmark-type" displacement analysis, Newmark, 1965). Seed (1979) calibrated his pseudo-static approach using Newmark displacements calculated with simplified methods (e.g., Makdisi and Seed, 1978). The Makdisi and Seed *simplified* procedure, in turn, is based on a limited number of calculations that were used to relate Newmark displacement to earthquake magnitude and k_y/k_{max} (e.g., five calculations for M = 6.5, two for M = 7.5, and two for M = 8.25). Seed's (1979) recommendations are an important milestone, as they represent the first calibration of a pseudo-static method to a particular level of slope performance as indexed by displacement. This concept underlies other widely used screen analysis procedures that have been developed to date, and is retained as well in the present work.

Since the Seed (1979) work, additional screen analysis procedures have been developed for application to earth dams and solid waste landfills. A procedure for earth dams was developed by Hynes-Griffin and Franklin (1984) based on (1) calculations of shaking within embankment sections using a linear elastic shear beam model by Sarma (1979) and (2) calculations of Newmark displacement from time histories using the analysis approach of Franklin and Chang (1977). Those calculations resulted in statistical relationships between the amplification of shaking within embankments (i.e., ratio of $k_{max} \times$ g to maximum horizontal acceleration of base rock, MHA_r) and the depth of the sliding surface, as well as between Newmark displacement and k_y/k_{max}. Hynes-Griffin and Franklin (1984) developed their pseudo-static procedure using approximately a 95th percentile value of amplification for deep sliding-surfaces along with the upper-bound value of k_y/k_{max} that produces 1.0 m of displacement. In the resulting procedure, k is taken as 0.5 × MHA_r, and the screen is passed if FS ≥ 1.0. The procedure is intended for use with 80% of the shear strength in non-degrading materials. The method is not recommended for

The screen analysis procedure developed herein is intended principally for application to hillside residential and commercial developments. For construction of this type, small ground deformations can cause collateral loss that is considered unacceptable by owners, insurers, and regulatory agencies. Accordingly, the limiting displacements used in existing screen procedures for earth dams and landfills are considered to be too large for application to hillside construction. Another problem with the existing procedures is the level of conservatism employed in their development. For example, the existing methods apply for specific ranges of earthquake magnitude (which are high for the Seed and Bray et al. methods), and may not pass otherwise safe sites for which the design magnitude is smaller than that used in the development of the screen. Moreover, the conservative interpretation of amplification and displacement distributions used in the development of existing schemes likely makes the level of risk associated with the slope performance differ significantly from that associated with the ground motions. In other words, if the ground motion is evaluated with probabilistic hazard analysis for a given return period, and the slope displacement conditioned on that ground motion is extreme (i.e., a rare realization), the resulting slope design is based on displacements having a much longer return period than the design-basis ground motion.

Given those shortcomings, the Committee has developed a new screen procedure tailored to the needs of hillside residential and commercial construction (in terms of displacement) and which accounts for site-specific seismicity. The screen procedure was also developed so as to control the level of conservatism in order to maintain a reasonable return period on the expected slope performance. The remainder of this appendix describes the development of the procedure.

DEVELOPMENT OF SCREEN ANALYSIS PROCEDURE

Introduction

The purpose of screen investigations for sites within zones of required study is to filter out sites that have no potential or low potential for earthquake-induced landslide development. No additional seismic stability analysis is required for a site that passes the screen, whereas further quantitative evaluation of landslide hazard potential (and possibly mitigation) is required for sites that fail the screen.

Like other screen procedures described in the previous section, ours is based on a pseudo-static representation of seismic slope stability. The procedure is implemented by entering a de-stabilizing horizontal seismic coefficient (k) into a conventional slope stability analysis. The seismic coefficient represents the fraction of the weight of the sliding mass that is applied as an equivalent horizontal force acting through the centroid of the mass. If the factor of safety is greater than one (FS > 1), the site passes the screen, and the site fails if FS < 1.

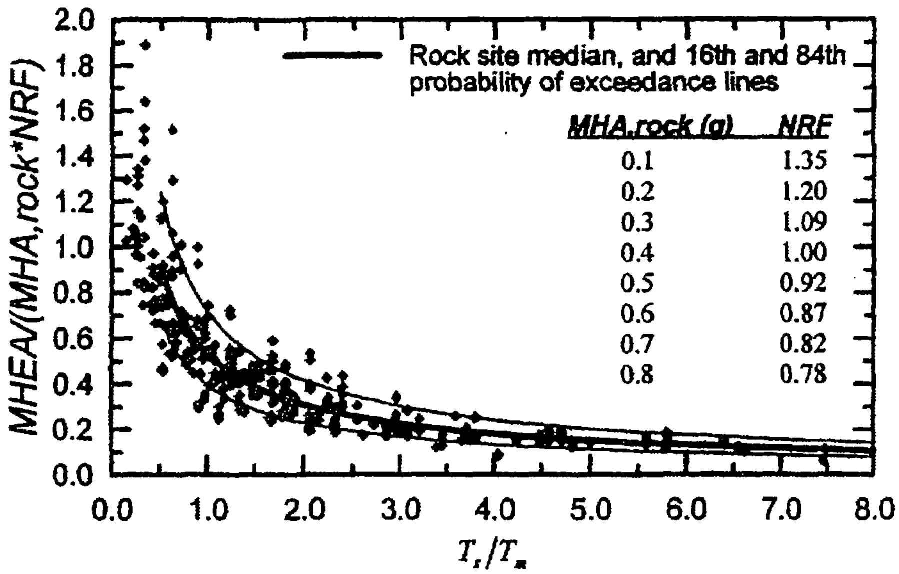

Fig. 1. Normalized MHEA for Deep-Seated Slide Surface vs. Normalized Fundamental Period of Slide Mass (after Bray et al., 1998).

The magnitude and distance that control the peak acceleration hazard in much of urban southern California are magnitude 6.5 – 7.0 earthquakes at distances generally less than 10 km (Petersen et al., 1996). Parameter T_m has a median value of about 0.5 s for these magnitude and distance ranges (Rathje et al., 1998). Parameter T_s is calculated as

$$T_s = \frac{4H}{V_s} \tag{3}$$

where H = thickness of slide mass and V_s = average shear wave velocity of slide mass. If V_s is taken as 300 m/s (consistent with soft bedrock or compacted fill materials), the slide mass thickness would have to exceed about 20 m for $T_s/T_m > 0.5$. It was therefore the Committee's judgment that MHEA/(MHA$_r$ × NRF) = 1.0 would be a reasonable assumption for sites having critical slip surfaces of moderate to shallow depth (< ~20 m), and would be conservative for deeper-seated slip surfaces (depth > ~20 m). Because parameter NRF is a function of MHA$_r$ (as shown in Figure 1) the assumption of MHEA/(MHA$_r$ × NRF) = 1.0 makes MHEA solely a function of MHA$_r$. Accordingly, Eq. 2 can be re-written as Eq. 1 provided the effect of NRF is incorporated into factor f_{eq}, which is done in the next section.

Formulation of Seismicity Factor f_{eq}

For a given MHA$_r$, large magnitude earthquakes will tend to cause poorer slope performance than smaller magnitude earthquakes. One important reason for this is that large magnitude earthquakes have longer durations of shaking. Previous pseudo-static procedures for seismic slope stability have specified a single value for f_{eq}, and thus have made implicit, and usually very

A relationship between magnitude, distance, MHA_r, and f_{eq} was established using the Bray and Rathje relationship with the following assumptions and observations:

1. Factor f_{eq}^* (Eq. 2) was taken as equivalent to k_y/k_{max}. The equivalency of k_y/k_{max} and f_{eq}^* can be understood by recognizing that k_y/k_{max} simply represents the factor by which the actual ground shaking intensity (k_{max}) needs to be reduced to render a seismic coefficient associated with FS = 1 (i.e., $k_y = k_y/k_{max} \times k_{max}$). Referring to Eq. 2, because our screen procedure is intended for use with FS = 1, f_{eq}^* represents the factor by which MHEA/g needs to be reduced to yield a seismic coefficient associated with FS = 1 (i.e., k_y). Accordingly, if k_y is substituted for k in Eq. 2 (appropriate for FS = 1) and k_{max} is substituted for MHEA/g, it can be readily seen that $f_{eq}^* = k_y/k_{max}$.
2. Parameter MHEA is inconvenient for use in a screen procedure because its relationship to MHA_r is affected by vertical ground motion incoherence effects and nonlinear ground response effects. As described in the previous section, to simplify the analysis we neglect the vertical incoherence effects, which is equivalent to assuming MHEA/($MHA_r \times$ NRF) = 1.0. From Eq. 1 and 2, we see that $f_{eq} = f_{eq}^* \times$ MHEA/MHA_r, which reduces to $f_{eq}^* \times$ NRF with the above assumption. Since $f_{eq}^* = k_y/k_{max}$, we calculate parameter $f_{eq} = k_y/k_{max} \times$ NRF.
3. Two threshold levels of Newmark displacement were selected by the Committee, u=5 and 15 cm. It should be noted that the Newmark displacement parameter is merely an index of slope performance. The 5 cm threshold value likely distinguishes conditions for which very little displacement is likely from conditions for which moderate or higher displacements are likely. The 15 cm value likely distinguishes conditions in which small to moderate displacement are likely from conditions where large displacements are likely. It should be noted that those threshold displacement values are smaller than values used in the development of existing screen procedures for dams and landfills. The Committee's use of the small displacement value is driven by a concern on the part of owners, insurers, and regulatory agencies to minimize collateral loss from slope deformations in future earthquakes.
4. Factor k_{max} is taken as $MHA_r \times$ NRF/g. Parameter D5-95 is a function of magnitude and distance, and can be estimated from available attenuation relationships.

Based on the above, calculations were performed to evaluate as a function of f_{eq} the probability that seismic slope displacement u > 5 cm conditional on MHA_r, magnitude, and distance. This probability is calculated as:

$$P(u > 5cm \mid MHA_r, M, r, f_{eq}) = \int_{D_{5-95}} f(D_{5-95} \mid m, r) P\left(u > 5cm \mid D_{5-95}(M,r), MHA_r, f_{eq}\right) d(D_{5-95}) \tag{5}$$

The distribution of median f_{eq} values with M, r, and MHA_r are shown in Figure 4(a) for u = 5 cm and in Figure 4(b) for u = 15 cm. The values in Figures 4 were derived using the Abrahamson and Silva (1996) attenuation model for duration at rock sites. Near-fault effects on ground motion parameters were neglected in the development of Figures 4; such effects would tend to increase the amplitude of long-period components of the ground motion but decrease the duration, and hence the net effect on seismic slope displacements would likely be small. Focal mechanism does not affect these calculations because the Abrahamson and Silva attenuation model for duration does not contain a focal mechanism term.

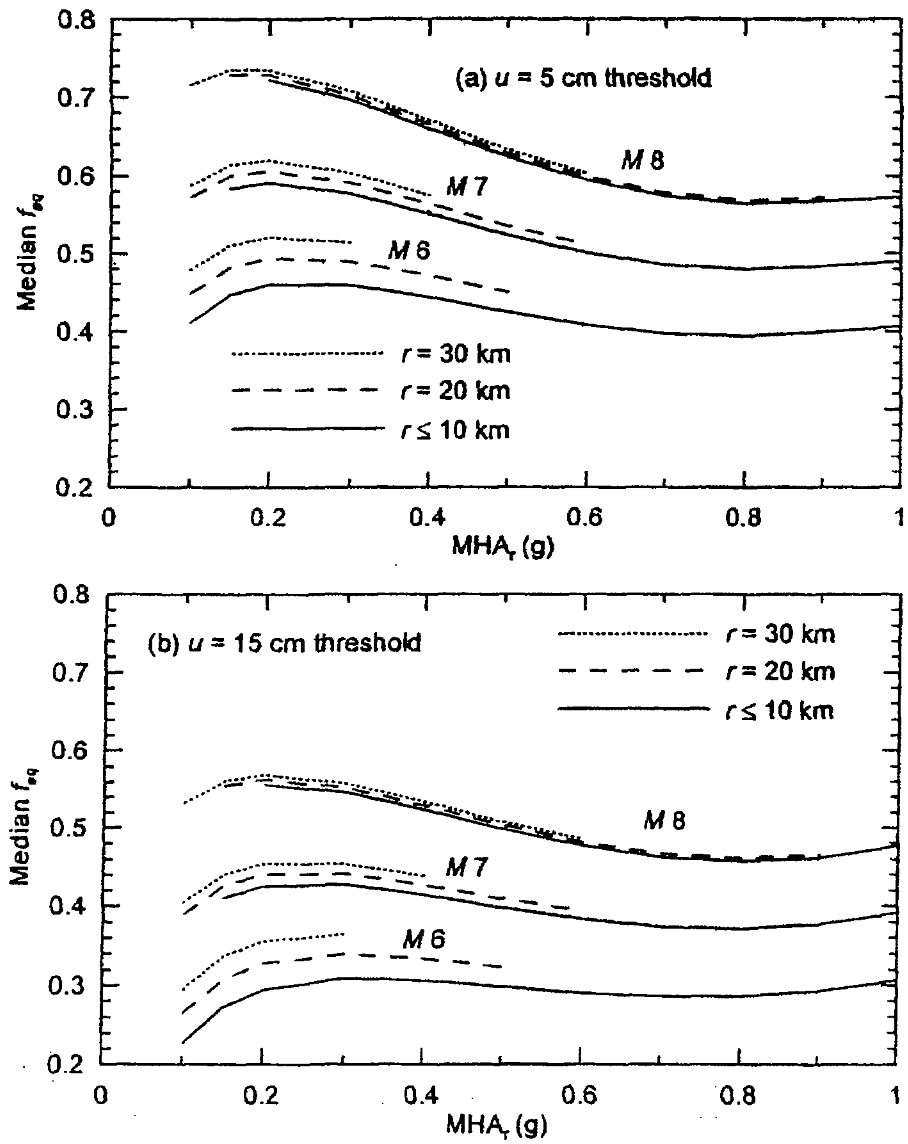

Fig. 4. Required Values of f_{eq} as Function of MHA_r and Seismological Condition for Acceptable Slope Performance

seismic hazard analysis (PSHA). The relative contributions of earthquake events at different magnitudes and distances to this MHA_r hazard should then be evaluated through a de-aggregation analysis, and the mode magnitude ($\overline{M}$) and mode distance ($\bar{r}$) identified for use in the screen. That combination of MHA_r, $\overline{M}$, and $\bar{r}$ represents the parameters that should be used to evaluate k. The Committee considered the use of supplemental deterministic seismic hazard analyses for sites located near large-magnitude, high slip-rate faults (such as the San Andreas fault system). However, it was found for many checked locations that k values computed deterministically were less than k values evaluated from PSHA. The PSHA results used in those checks are from published State-wide maps (Petersen et al., 1996). In our checks, the deterministic k values were evaluated using the characteristic earthquake event (as compiled by Petersen et al., 1996) on the largest fault segment nearest the site, and the 84th percentile MHA_r value associated with that characteristic event. The Committee recognizes that more severe deterministic scenario events could be conceived, but those would likely be sufficiently rare as to have a return period that significantly exceeds the 475-year target.

Limitations

As with other screen analysis procedures, the present procedure should not be used for slopes comprised of geologic materials that could be subject to significant strain softening, such as liquefiable soil. The procedure is not applicable to slopes constructed over soft clay soil, because as noted previously the Bray et al. (1998) relationship for MHEA (Figure 1) does not apply for that site condition. The procedure also should not be applied to situations for which 5 cm (or 15 cm) displacement is an inappropriate displacement threshold. Finally, it should be noted that this screen analysis procedure, and any analysis of seismic slope stability based on Newmark sliding block models, only provides an index of slope performance that is related to the accumulation of permanent shear deformations within the ground. Volumetric ground deformations associated with post-liquefaction pore-pressure dissipation or seismic compression of unsaturated ground are not considered in Newmark-type models and need to be evaluated separately.

Examples

Seismic coefficients (k) for three example sites in southern California are evaluated to illustrate application of the screen procedure defined by Eqs. 1 and 6. Locations of the sites are shown in Figure 5. The site denoted "Los Angeles" in Figure 5 is on the north flank of the Santa Monica Mountains, and is not immediately adjacent to any major active fault systems. The site denoted "Glendale" is near the base of the San Gabriel Mountains, and is close to the Sierra Madre fault system. The site at the intersection of Highway 138 and Interstate Highway 5 is adjacent to the San Andreas fault.

It should also be noted that the $\overline{M}$ values indicated in Table 1 are consistent with the characteristic earthquake magnitudes for faults near the respective sites (as tabulated in Petersen et al., 1996). The similarity of those magnitudes is the principal reason that the Committee does not consider it necessary to perform supplemental deterministic analyses of scenario events (which would have a magnitude similar to the characteristic earthquake magnitude).

Post-Screen Analysis

For sites that fail the screen analysis, more detailed slope displacement calculations should be performed. Several alternative analysis procedures are recommended by the Committee. Those include simplified analysis of Newmark displacement using the procedures formulated by Makdisi and Seed (1978) or Bray and Rathje (1998), or formal Newmark analysis of sliding block displacements using appropriate integration techniques with applicable earthquake time histories. Those procedures are well documented in the literature, and are summarized in Chapter 11 of the attached report.

CONCLUSIONS

In this appendix, we have presented a screen analysis procedure for seismic slope stability that takes into account local variations in seismicity, as represented by the magnitude (M) and distance (r) that most significantly contribute to the ground motion hazard at a site. The screen procedure is based on a statistical relationship previously developed by Bray and Rathje (1998) between seismic slope displacement (u), peak amplitude of shaking in the slide mass (k_{max}), significant duration of shaking ($D_{5\text{-}95}$), and the ratio of slope resistance to peak demand (k_y/k_{max}). The screen is formulated to separate sites expected to undergo small to negligible slope deformation from sites where larger and more damaging slope movements are likely. Application of the screen is straightforward. Pseudo-static seismic coefficient k is calculated using Eq. 1, with the parameter f_{eq} in Eq. 1 evaluated using Figure 4 based on the site seismicity and the tolerable slope displacement.

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APPENDIX 6.3
Landfill Design Calculations

APPENDIX D

LANDFILL DESIGN CALCULATIONS

FLOOR ELEVATIONS

LEACHATE WITHDRAWAL PIPES

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL

LEACHATE COLLECTION SYSTEM

GEOTEXTILE FILTER FABRIC

SUMP CAPACITY

GCL HYDRAULIC COMPATIBILITY

WASTE RUNOFF CONTAINMENT

FLOOR ELEVATION

Client: ECDC Environmental
Project: Wasatch Regional Landfill
Feature: Floor Elevation Calculations
Date: December 2004. **REVISED JUNE 2005 *(corrected and updated table - represents modified trench location and model)***

Description: Set the low point of each floor or leachate management area (phase) based on future groundwater projections and on potential settlement estimates.

Settlement: Assuming embankments approximately 15 feet high above existing ground surface, interior embankment slopes of 2H:1V, excavation to the cell floor of approximately 5 feet, and closure cap slopes of 4H:1V.

Horizontal distance to the floor from the top of the cell embankments is 20' x 2 = 40' from the top of the cell embankment to the low point of the phase area. Height of the closure cap above the embankment a the location of the low point of the sub-cell area is 40/4 = 10'. Total fill height above existing ground surface to the closure cap in the area of the sump is 15 + 10 = 25 feet.

If settlement is 3% of the fill height above existing grade, then 25 x 0.03 = 0.75 feet settlement. if the fill height increases to 30 feet above existing grade in the area of the sumps, then settlement is 30 x 0.03 = 0.90 feet.

Determine the low point elevation of each sub-cell area.

Provide a minimum ground water separation of the required 5 feet plus an additional foot for settlement and an additional 2.2 feet for modeling accuracy. Therefore, provide a minimum of 8.2 feet of separation.

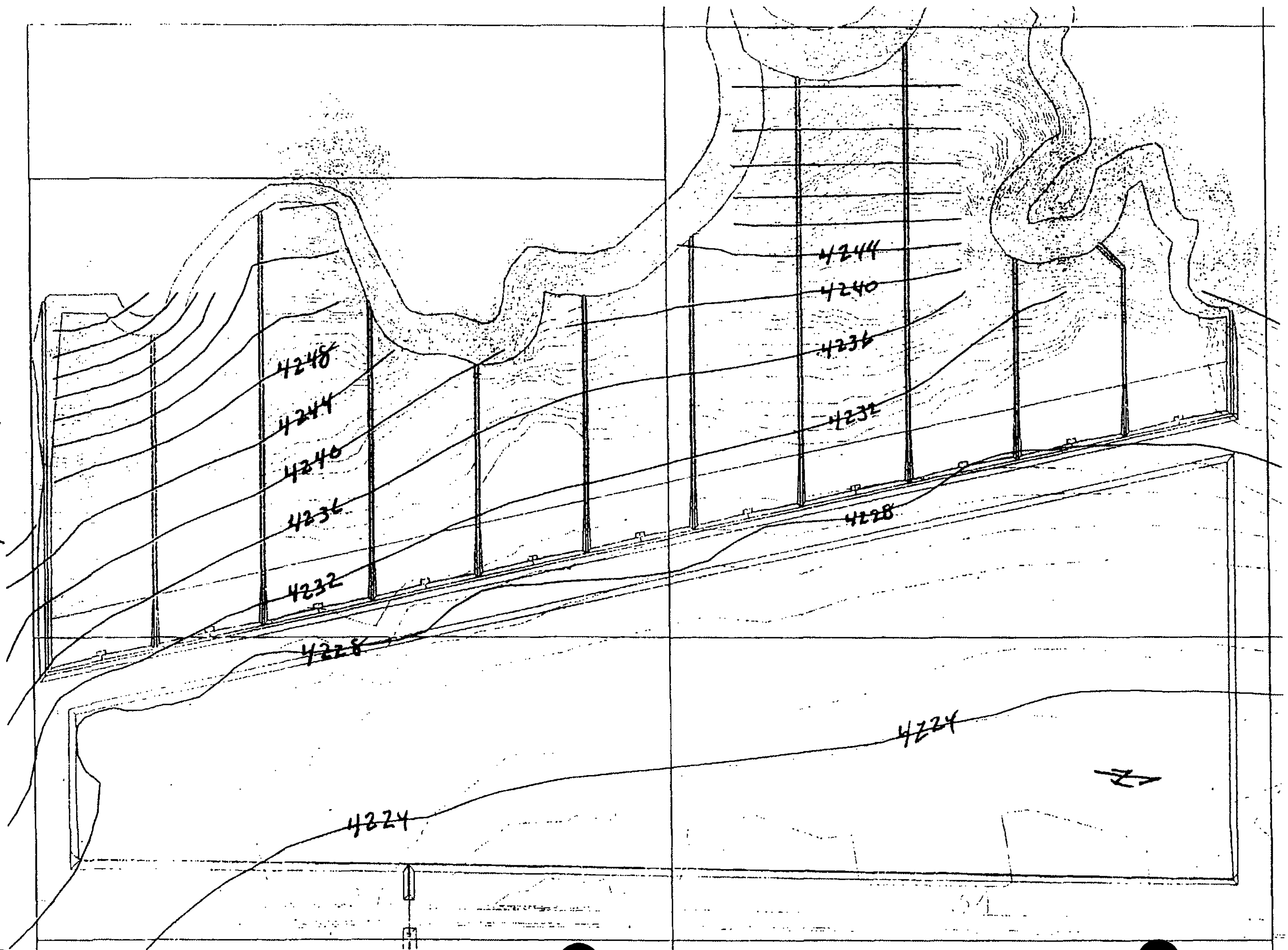
Cell phases are designated as Phase 1 being the southmost phase and Phase 11 being the northmost phase.

Landfill Area					
Phase	**Ground Surface Elevation**	**Ground Water Elevation**	**Calc. Sump Potential Low point Elevations**	**Design Sump Low point Elevations**	**Separation to Projected High Ground Water**
1	4249.2	4233.6	4239.6	4243.5	9.9
2	4249.7	4231.6	4237.6	4243.5	11.9
3	4246.8	4230.8	4236.8	4243.5	12.7
4	4246.2	4230.0	4236.0	4243.5	13.5
5	4246.1	4229.2	4235.2	4243.5	14.3
6	4246.2	4229.5	4235.5	4243.5	14.0
7	4247.1	4229.0	4235.0	4243.5	14.5
8	4247.9	4229.1	4235.1	4243.5	14.4
9	4248.2	4228.1	4234.1	4243.5	15.4
10	4248.4	4228.1	4234.1	4243.5	15.4
11	4248.9	4228.7	4234.7	4243.5	14.8

Design the cell with all sump areas identical in configuration and elevation. The minimum design elevation for the sumps is 4241.8 to maintain 8.2 feet of separation between the sump liner system and the projected high ground water elevation.

The low points of the sumps are set at 4243.5 which provides a minimum separation of 9.9 feet to projected high ground water elevation.

Projected Ground Water Contours



1. Determine floor slopes required to maintain minimum slopes after accounting for potential differential settlement. Assume that the minimum planar slopes where geonet provides the drainage medium will be 2% after settlement and the minimum slopes for the leachate conveyance pipes will be 1% after settlement.

   a. Planar Slopes

      The worst case scenario for the planar slopes are those planes whose slopes are parallel to the slope of the closure caps. The floor slopes go up gradient toward the peak of the closure cap, thus, causing differential settlement that lessens the floor slope.

      Assuming a 100 foot wide sloping surface results in a rise of 2 feet on a 2% sloping floor surface. That same distance on the 4H:1V cap slope results on a rise of 25 feet. Therefore, the additional fill height for the waste pile and closure cap across the 100 foot wide surface is 25 feet resulting in a projected settlement amount of 0.50 foot to 0.75 foot at the up gradient side of the slope (2% to 3%). Adding an additional height of 0.50 foot to 0.75 foot to the 2 feet resulting from the 2% grade gives a resulting up gradient height of 2.5 feet to 2.75 feet. The resulting design slope should, therefore, be between 2.5% (2.5/100) and 2.75% (2.75/100). Design the slopes at 2.75%.

   b. Leachate Conveyance Pipe Slopes

      i. There are three different types of conditions to the leachate conveyance pipes on the cell floor. Pipes extend toward the west from the low point in the sumps to a point below the break line in the closure cap between the 4H:1V slope and the 5% cap slope; toward the west from the break line in the closure cap between the 4H:1V slope and the 5% cap slope to the west end of the cell; and pipes that extend along the inside toe of the east embankment slope. Each of the pipe configurations will be addressed separately.

         (1) Extending west from the low point in the sumps to a point below the break line in the closure cap between the 4H:1V slope and the 5% cap slope.

             These leachate conveyance pipes are located directly under the 4H:1V slope of the closure cap and their slopes are adversely effected by differential settlement.

             Assuming a 100 foot long length of pipe results in a rise of 1 foot on a 1% slope. That same distance on the 4H:1V cap slope results on a rise of 25 feet. Therefore, the additional fill height for the waste pile and closure cap along the 100 foot length of pipe is 25 feet resulting in a projected settlement amount of 0.50 foot to 0.75 foot at the up gradient side of the slope (2% to 3%). Adding an additional height of 0.50 foot to 0.75 foot to the 2 feet resulting from the 2% grade gives a resulting up gradient height of 1.5 feet to 1.75 feet. The resulting design slope should, therefore, be between 1.5% (1.5/100) and 1.75% (1.75/100). Design the slopes at 1.7%.

(2) Extending toward the west from the break line in the closure cap between the 4H:1V slope and the 5% cap slope to the west end of the cell.

Assuming a 100 foot long length of pipe results in a rise of 1 foot on a 1% slope. That same distance on the 5% cap slope results on a rise of 5 feet. Therefore, the additional fill height for the waste pile and closure cap along the 100 foot length of pipe is 5 feet resulting in a projected settlement amount of 0.10 foot to 0.15 foot at the up gradient side of the slope (2% to 3%). Adding an additional height of 0.10 foot to 0.15 foot to the 1 foot resulting from the 1% grade gives a resulting up gradient height of 1.1 feet to 1.15 feet. The resulting design slope should, therefore, be between 1.1% (1.1/100) and 1.15% (1.15/100). Design the slopes at 1.2%.

(3) Extend along the inside toe of the east embankment slope

Leachate collection pipes running parallel to the contour of the closure cap can be designed at a 1% slope since fill height does not increase along the length of the pipes and differential settlement is not projected to occur.

LEACHATE WITHDRAWAL

I. Evaluate the long-term strength of the HDPE pipe against failure or significant loss of cross-sectional area.

Reference Manuals: "Design & Engineering Guide for Polyethylene Piping", by Rinker Materials, August 2003.

"Plexco/Spirolite Engineering Manual 2. System Design", by Chevron Chemical Co., April 1996.

Design Criteria:

Pipe Diameters = 24 inches - top and bottom pipes.
Maximum Design Height of Overburden = 250 feet (See attached drawing)
Note: Maximum height of overburden on the design drawing is 235.8 feet. However a larger design height was selected to account for uncertainties in the construction and filling of the landfill, as well as additional load applied by the operation equipment over the landfill.

Unit weight of overburden:

Soil cover	= 125	pcf
Waste	= 80	pcf

A. Soil Pressure by components

$$P_T = P_S + P_L$$

where: P_T = Total load pressure
P_S = Static or dead load pressure
P_L = Live load pressure

Using the Boussinesq's Equation from the manual reference above, the live load pressure can be estimated as follows

$$P_L = \frac{3W_L H^3}{2\pi * R^5}$$

W_L = wheel load (lb)
H = vertical depth of crown
R = distance from the point load application to the crown

Assuming a tire load of 4,000 pound, then the live load on the pipe would be as follows

$$P_L = \frac{3(4000)(250)^3}{2\pi * (250)^5}$$

P_L = 0.03 psf (load is insignificant to the dead load and will be excluded)

Therefore, only the dead load will be used to pipe strength design.

P_T = P_S = height of overburden x unit weight of overburden
$P_{T24"}$ = (2' + 2' + 3')(125 pcf) + (95')(80 pcf) + (10')(62.4)

= 9,099 psf = 63.2 psi for the 24" pipe

$P_{T16"}$ = (2' + 2' + 3')(125 pcf) + (91')(80 pcf) + (10')(62.4)

= 8,779 psf = 61.0 psi for the 16" pipe

B. Evaluate Wall Crushing

The compression stress on the pipe walls is given below:

$$S = \frac{P_L D_O}{288t}$$

S = Compressive stress (psi)
P_L = vertical load applied to pipe (psf)
t = wall thickness (in)
D_O = outside diameter of pipe (in)

The maximum long-term design stress value for Plexco polyethylene pipe is 800 psi. The ratio of pipe diameter to wall thickness is given below.

$$\frac{D_O}{t} = \frac{288(800)}{9{,}099\,psf}$$

$$\frac{D_O}{t} = 25.3$$

Therefore a SDR of 25 or lower should be strong enough to avoid crushing failure.

C. Evaluate Wall Buckling

Wall buckling resistance of pipe is increased when it is buried. The soil and pipe work together to resist buckling. AWWA C-950 gives a design equation for buckling of buried plastic pipe which is applicable to PLEXCO pipe.

$$P_{ch} = \frac{1}{SF}\sqrt{\left(\frac{2.67 \cdot R_w \cdot B \cdot E_s \cdot E}{DR^3}\right)}$$

P_{cb} = Critical buckling stress (psi)
SF = Safety factor,
R_w = Water buoyancy factor, (dimensionless)
B = Empirical Coefficient of Elastic Support (dimensionless)
E_s = Soil modulus, (See Table C-4)
E = Pipe modulus of elasticity, psi
DR = Dimension ratio

Where,

$$R = 1 - \left(0.33 \cdot \frac{H_w}{H}\right)$$

H_w = Height of water table above the pipe (ft)
The embankment is 10 ft high, so the maximum water height will be 10 ft
H = Height of soil cover above pipe (ft)
The cover over the sump area is about 102 ft

$$B = \frac{1}{1 + 4e^{(-0.065H)}}$$

e = Natural log base number
H = Height of soil cover above pipe (ft)

For the 24" pipe:

$$P_{cb} = \frac{1}{2}\sqrt{\frac{2.67 \cdot (0.968) \cdot (0.995) \cdot (30{,}000psi)(1600psi)}{(15.5)^3}}$$

$$P_{cb} = 91.0psi$$

$$R = 1 - 0.33\frac{10'}{102}$$

$$R = 0.968$$

$$B = \frac{1}{1 + 4e^{(-0.065(102))}}$$

$$B = 0.995$$

The pipe should not buckle since the calculated buckling resistance of 91.0 psi exceeds the 63.2 psi loading on pipe.

For the 16" pipe:

$$P_{cb} = \frac{1}{2}\sqrt{\frac{2.67 \cdot (0.966) \cdot (0.993) \cdot (30{,}000psi)(1000psi)}{(15.5)^3}}$$

$$P_{cb} = 71.8psi$$

$$R = 1 - 0.33\frac{10'}{98}$$

$$R = 0.966$$

$$B = \frac{1}{1 + 4e^{(-0.065(98))}}$$

$$B = 0.993$$

The pipe should not buckle since the calculated buckling resistance of 71.8 psi exceeds the 61.0 psi loading on pipe.

D. Evaluate Ring Deflection

Ring deflections are calculated using the following modified Spangler's equation:

$$\Delta X = \frac{D_l \cdot K \cdot W}{\left(\frac{2E}{3(DR-1)^3}\right) + 0.061E'}$$

ΔX = Horizontal deflection (in.)
D_l = Deflection lag factor, PolyPipe recommends 1.0 (dimensionless)
K = Bedding constant, Polypipe recommends 0.1 (dimensionless)
W = Earthload (lbs/inch)
E = Modulus of elasticity of pipe, 30,000 psi
E' = Soil modulus
DR = Dimension ratio

For the 24" pipe:

$$\Delta X = \frac{1 \cdot 0.1 \cdot (63.2 \cdot 24)}{\left(\frac{2 \cdot 30{,}000}{3(15.5-1)^3}\right) + 0.061 \cdot 1600}$$

$$\Delta X = 1.46 in$$

The percent deflection is calculated using the following formula:

$$d = \frac{\Delta X}{D} \cdot 100$$

d = Percent deflection (%)
ΔX = Horizontal deflection (in.)
D = Outside diameter (in.)

$$d = \frac{1.46}{24} \cdot 100$$
$$d = 6.07\%$$

To see if this deflection could cause failure in the pipe the ring bending strain was computed below. This equation is provided in the Plexco/Spirolite Engineering Manual.

$$\varepsilon = f_D \frac{\Delta Y}{D_M} \frac{2C}{D_M}$$

C = 0.53t = 0.53 *1.548 = 0.82

ε = wall strain, (%)
f_d = deformation shape factor
D_M = mean diameter (in)
C = outer fiber to wall centroid (in)
t = pipe minimum wall thickness

$$\varepsilon = 6\frac{1.46}{22.36}\frac{2(0.82)}{22.36}$$
$$\varepsilon = 0.0287 = 2.87\%$$

The PLEXCO design manual references a study by Jansen that states strains of 8% should perform well for at least 50 years. ISCO industries also lists its high density polyethylene pipe as having an elongation at yield of 8%.

For the 16" pipe:

$$\Delta X = \frac{1 \cdot 0.1 \cdot (61.0 \cdot 16)}{\left(\frac{2 \cdot 30{,}000}{3(15.5 - 1)^3}\right) + 0.061 \cdot 1000}$$

$$\Delta X = 1.44in$$

The percent deflection is calculated using the following formula:

$$d = \frac{\Delta X}{D} \cdot 100$$

d = Percent deflection (%)
ΔX = Horizontal deflection (in.)
D = Outside diameter (in.)

$$d = \frac{1.44}{16} \cdot 100$$
$$d = 9.03\%$$

To see if this deflection could cause failure in the pipe the ring bending strain was computed below. This equation is provided in the Plexco/Spirolite Engineering Manual.

$$\varepsilon = f_D \frac{\Delta Y}{D_M}\frac{2C}{D_M}$$

C = 0.53t = 0.53 *1.032= 0.547

ε = wall strain, (%)

f_d = deformation shape factor
D_M = mean diameter (in)
C = outer fiber to wall centroid (in)
t = pipe minimum wall thickness

$$\varepsilon = 6\frac{1.44}{14.91}\frac{2(0.547)}{14.91}$$
$$\varepsilon = 0.0425 = 4.25\%$$

The PLEXCO design manual references a study by Jansen that states strains of 8% should perform well for at least 50 years. ISCO industries also lists its high density polyethylene pipe as having an elongation at yield of 8%.

II. Check the required length of HDPE pipe to allow for contraction/expansion due to thermal changes.

A. Differential Pipe Length Due to Temperature Changes

The bottom pipes will be backfilled and therefore not exposed to extreme temperature fluctuations. However the top pipe will be exposed during construction and may experience large temperature variations.

Assume maximum $\Delta T = 100° - 10° = 90°$

$$\Delta L = \alpha \times \Delta T \times L$$

$$L = 21.2'$$

α = coefficient of thermal expansion
$\alpha = 1.0 \times 10^{-4}$ in/in/°F
L = pipe length in feet

$\Delta L = (1.0 \times 10^{-4}$ in/in/°F)(90°F)(15')(12 in/ft) = 1.62 in. = 0.135 ft.

Only approximately 15' of the top of the pipe will be exposed to the thermal fluctuations assumed above. This amount of expansion and contraction is well within the 8% discussed previously.

High Density Polyethylene

HDPE CHARACTERISTICS
TYPICAL PROPERTIES
CHEMICAL RESISTANCE CHART
SIZE AND DIMENSION CHARTS BY APPLICATION
CALCULATION PROGRAMS

SEARCH

ISCO Solutions
- HDPE Pipe
- Pipe Joining Equipment
- Custom HDPE Fabrication
- HDPE Fittings
- Snap-Tite Culvert Liners
- Buttress-Loc Sewer Liners

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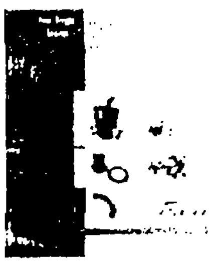

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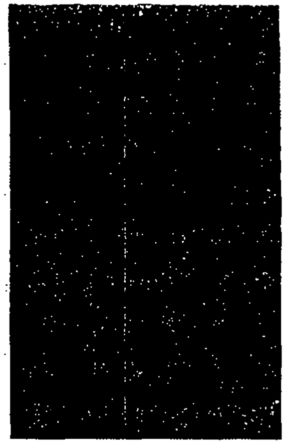
TYPICAL PROPERTIES

HIGH DENSITY POLYETHYLENE PIPE
Typical Physical Properties***

Property	Specification	Unit	Nominal Value
Material Designation	PPI / ASTM		PE 3408
Material Classification	ASTM D-1248		III C 5 P34
Cell Classification	ASTM D3350-99		345464C
-Density (3)	ASTM D-1505	gm/cm3	0.955
-Melt Index (4)	ASTM D-1238 (216 kg/190iC)	gm/10 min.	0.11*
-Flex Modulus (5)	ASTM D-790	psi	135,000
-Tensile Strength (4)	ASTM D-638	psi	3,200
PENT (6)	ASTM F-1473	Hours	>100
-HDB @73i F (4)	ASTM D-2837	psi	1,600
-HDB @ 140 Deg F	ASTM D-2837	psi	800
-U-V Stabilizer (C)	ASTM D-1603	% C	2.5
Hardness	ASTM D-2240	Shore "D"	65
Compressive Strength (yield)	ASTM D-695	psi	1,600
Tensile Strength @ Yield (Type IV Spec.)	ASTM D-638 (2"/min.)	psi	3,200
Elongation @ Yield	ASTM D-638	%, minimum	8
Tensile Strength @ Break (Type IV Spec.)	ASTM D-638	psi	5,000
Elongation @ Break	ASTM D-638	%, minimum	750
Modulus of Elasticity	ASTM D-638	psi	130,000

PENT (6)	ASTM F-1473	Hours	>100
(Cond. A, B, C: Mold. Slab)	ASTM D-1693	Fo, Hours	>5,000
(Compressed Ring - pipe)	ASTM F-1248	Fo, Hours	>3,500
Slow Crack Growth	Battelle Method	Days to Failure	>64
Impact Strength (IZOD) (.125Ó Thick)	ASTM D-256 (Method A)	In-lb / in notch	42
Linear Thermal Expansion Coef.	ASTM D-696	in / in/iF	1.2x10-4
Thermal Conductivity	ASTM D-177	BTU-in/ft2/ hrs/ degreesF	2.7
Brittleness Temp.	ASTM D-746	degrees F	< -180
Vicat Soft. Temp.	ASTM D-1525	degrees F	257
Heat Fusion Cond.	ASTM D-1525	@ psi degrees F	75 @ 400



*** This list of typical physical properties is intended for basic characterization of the material and does not represent specific determinations of specifications. The physical properties values reported herein were determined on compression molded specimens prepared in accordance with Procedure C of ASTM D 1928 and may differ from specimens taken from pipe.
** Tests were discontinued because no failures and no indication of stress crackinitiation.
* Average Melt Index value with a standard deviation of 0.01

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Pipe Stiffness

for

Buried Gravity Flow Pipes

TN-19/2000

Foreword

This report was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical note is to provide general information on pipe stiffness for buried, gravity flow pipes.

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The Plastics Pipe Institute
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April, 2000

PIPE STIFFNESS FOR BURIED GRAVITY FLOW PIPES

Various measures have been used to characterize the ring bending stiffness of pipe. In the U.S., these measures include:

- Flexibility Factor (FF) as defined in AASHTO Bridge Design Specification Section 18,
- Pipe Stiffness (PS) as defined in ASTM D 2412, and
- Ring Stiffness Constant (RSC) as defined in ASTM F 894.

These measures characterize the pipe's resistance to ring deflection when subjected to a short-term parallel plate load. The purpose of this note is to advise on the applicability of these measures for comparing and classifying plastic pipes.

The first commonly used measure for pipe deflection resistance was pipe stiffness (PS). Designers found it easy to assign a minimum PS value in their specifications for plastic pipes. However, for larger diameter pipes, the validity of PS as a product specification requirement has been questioned because:

(1) It was discovered that given the same handling and installation forces smaller diameter pipes require much higher stiffness for proper installation than do larger diameter pipes.

(2) It was found that there was a trade-off between pipe material strain capacity and pipe stiffness. Pipes made from strain limited plastics such as glass-reinforced thermoset resin required greater stiffness to restrain localized deflections than that required for thermoplastic pipes.

HANDLING AND INSTALLATION

Pipe intended for buried applications must be sufficiently stiff to resist deflection due to shipping, handling, and storage loads as well as the loads applied during installation. The most significant of these loads is the force exerted on the pipe during mechanical compaction of the soil. This force can cause the pipe to undergo deformations that will be exacerbated by soil loads during the subsequent placement of backfill. The force exerted on the pipe during compaction can be treated as a line load that is primarily a function of the compaction method and soil type and is relatively independent of the pipe's diameter.

When pipes of equal PS but different diameters are subject to equal line loads, the deflection response in percent is a function of its diameter. For a given line load, the deflection of a pipe can be calculated from the PS equation:

$$PS = \frac{F}{\Delta Y} = \frac{EI}{.149\, r_m^3} \qquad (1)$$

Where:	F	=	Load (lbs./lineal-in)
	ÄY	=	Deflection (in)
	E	=	Modulus of Elasticity (psi)
	I	=	Cross Sectional Moment of Inertia (in^4/in)
	r_m	=	Mean Radius (in)

The difficulty encountered when trying to classify pipes of different diameters using PS can be seen by comparing the deflection response of 12" pipe with a 60" pipe both having a PS of 50 psi and both subjected to a 50 lbs/lineal-in parallel plate load. Both pipes will deflect one inch per Eq. 1. However, when deflection is calculated in percentage as it normally is for buried pipes, the 12" pipe deflects 8.3 percent of its initial diameter while the 60" pipe deflects only 1.7 percent. From this, the conclusion can be drawn that PS is not very useful for classifying pipes of different diameters in regard to installation forces. Given the same handling and installation forces it can be seen that smaller diameter pipes require more PS than larger diameter pipes.

The above discussion leads to the conclusion that any workable minimum stiffness requirement has to be diameter weighted. This can be done by "weighting" the PS equation. The PS equation can be weighted by multiplying both sides of Eq. 1 by the mean diameter. The result of this multiplication, after rearranging terms is given in Eq. 2.

$$\frac{\frac{F}{\Delta Y}}{D_m} = \frac{8EI}{.149\, D_m^3} \qquad (2)$$

If the load in Eq. 2 is expressed in lbs/ft instead of lbs/in and if deflection is expressed in units of percent, Eq. 2 becomes:

$$RSC = \frac{F}{\frac{\Delta Y}{D_m}}\left(\frac{12}{100}\right) = \frac{6.44EI}{D_m^3} \qquad (3)$$

Eq. 3 is the mathematical expression of RSC. It can be shown that subjecting a 12" pipe and a 60" pipe of equal RSC to an equal parallel plate load would produce an equal percent deflection. The FF is merely the inverse of the RSC multiplied by a constant. Therefore, both the FF and RSC produce equal deflection responses and can be used to classify pipes.

What minimum value of RSC is necessary to provide sufficient resistance to handling and installation forces? ASTM F 894 anticipates up to 3 percent out-of-roundness for pipe prior to earthloading. Therefore, the pipe should be able to withstand normal handling and installation loads, such as the force transmitted to the pipe due to machine compaction of the embedment, without exceeding 3 percent out-of-roundness. (This is not to be confused with the deflection limit applied to deflections due to backfill and live loads.) Field measurements reported by Petroff [1] show that HDPE pipes with RSC of 40 possess sufficient stiffness to resist normal handling and installation loading and remain within 3 percent out-of-roundness when installed in accordance with ASTM D 2321 or PPI TR-31.

It should be noted that the ASTM test methods for RSC and PS differ. The RSC test is done at a load rate of 2 in/min as opposed to 0.5 in/min for PS. And, RSC is measured at 3.0 percent deflection whereas PS is measured at 5.0 percent. Because of these differences when the expression in Eq. 3 is used to convert from RSC to PS, the F/ÄY value given by Eq. 3 should be multiplied by an empirical factor for HDPE of 0.8. (This factor can vary with material.)

This section has shown that as the diameter of a pipe increases, less stiffness is required to achieve the same capacity for handling and installation. For instance, a 72" pipe with a tested RSC of 40 would have a PS of 4.6 psi. This PS may seem low, but the RSC is sufficient for handling and installation. However, a PS of 4.6 psi would typically be insufficient for a small diameter pipe. Consider a 6" pipe with the same PS (4.6 psi). It would have an RSC of 4.2, which is far below the minimum 40 required for proper installation. As a matter of fact a 6" pipe having a 46-psi stiffness would have an RSC of 41.4. So, the minimum RSC requirement of 40 is consistent with the early experience of the plastic pipe manufacturers in that a relatively high stiffness was required for proper installation.

STRAIN CAPACITY

When designing buried applications, the designer can make a trade-off between the strain capacity of the pipe material and the pipe's stiffness. When subjected to earth loads, strain occurs in the pipe wall as a result of deformations due to both ring bending and ring thrust. If a pipe material has a low tolerance for strain, it is usually necessary to limit the strain by limiting the pipe deformation. There are two levels of deformation in a buried pipe. One is standard diametrical deflection due to earth load; the other is a second order deformation due to non-elliptical deformation. Second order deformations are small but may induce high strains. They are directly proportional to the pipe's ring stiffness. These deformations are of little consequence with HDPE pipes, because of the high strain capacity. Janson recently completed an eight-year study on pressure-rated grade HDPE and reports that for practical design purposes (for gravity sewers) there does not seem to be an upper limit on design strain [2]. This essentially means that when using pressure-rated grades of HDPE, a designer does not have to be concerned with the strains occurring from second order deformations, assuming overall deflection and buckling are controlled.

BURIED PERFORMANCE

Buried pipe must possess sufficient stiffness to mobilize soil resistance in the backfill and to resist buckling. Deflection must be limited to a value that will not disrupt flow or cause joint leakage. The considerable field experience with stress-rated HDPE pipes of high SDR's and over 25 years experience with stress-rated HDPE, profile wall pipes speaks to the capability of low stiffness pipes to perform under soil loads.

Flexible pipe deflection depends on the combined contribution of pipe ring bending stiffness and embedment soil stiffness (E'). Considerable testing and field measurements have established that for low stiffness pipes the deflection is virtually controlled by the embedment soil. This is true for any flexible pipe, whether metal or plastic. Spangler's Iowa formula can be used to demonstrate that the soil's contribution to resisting deflection is much more significant than the pipe's contribution. Although Spangler's equation was developed using pipes of 25-psi stiffness and higher, considerable field experience has shown its applicability to low stiffness pipes [3]. When pipes of 46 psi PS and, say, 4.6 psi PS are installed with E's normally associated with pipe installations, there is little difference in their deflection. On the other hand when pipe is not installed properly a low E' results in both the 46 psi and 4.6 psi deflecting excessively. It can be shown mathematically that a 46 psi pipe supplies a stiffness to the soil/pipe system equivalent to a soil with an E' of 112 which offers hardly any resistance to deflection. Therefore, whether the PS is 46 psi or 4.6 psi as in the example above, the soil placement will control deflection.

The principle of soil embedment controlling deflection has been illustrated over and over again in field tests and numerous soil box demonstrations. For instance, one soil box test conducted at Utah State University on a 21" HDPE pipe with a stiffness of 6.4 psi installed in silty sand at 92 percent of Standard Proctor density resulted in 3 percent deflection with a loading equivalent to 90 feet of soil backfill.

Publications by Chua and Lytton [4], Watkins et al [5], Gaube and Muller [6], Taprogge [7], Janson and Molin [8], Selig [9], and Gabriel [10] all speak to the fact that the pipe's *stiffness makes only a minimal contribution to deflection resistance.*

References:

[1] Petroff, L.J. (1985). "Stiffness Requirements of HDPE, Profile Wall Pipe", Proc. Int. Conf. on Advances in Underground Pipeline Engineering, ASCE, Madison, WI.

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[3] Chua, K.M. and Petroff, L.J. (1988). "Predicting Performance of Large Diameter Buried Flexible Pipe", Proc. Second Int. Conf. on Case Histories in Geotechnical Engineering, St. Louis.

[4] Chua, K. M. and Lytton, R. L. (1987). "A New Method of Time-Dependent Analysis for Interaction of Soil and Large-Diameter Flexible Pipe." 66th Annual Mtg., Transp. Res. Board, Washington, D.C.

[5] Watkins, R.K., Szpak, E., and Allman, W.B. (1974). "Structural Design of PE Pipes Subjected to External Loads", Engr. Experiment Station, Utah State Univ., Logan.

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[8] Janson, L.E. and Molin, J. (1981). "Design and Installation of Underground Plastic Sewer Pipe", Proc. Int. Conf. on Underground Plastic Pipe, ASCE, New Orleans.

[9] Selig, E. T. (1990). "Flexible Pipe Design-Accomplishments and Challenges", Conference on Flexible Pipes, Columbus, Ohio.

[10] Gabriel, L.H. (1990). "Keynote address: Pipe Deflection-A Redeemable Asset", Conference on Flexible Pipes, Columbus, Ohio.

Table A-2 (cont)
PIPE WEIGHTS AND DIMENSIONS *(IPS)*
PE3408 *(BLACK)*

OD Nominal in.	OD Actual in.	OD Actual mm.	SDR	Nominal ID in.	Nominal ID mm.	Minimum Wall in.	Minimum Wall mm.	Weight lb. per foot	Weight kg. per meter
			9	18.45	468.71	2.667	67.73	77.845	115.847
			9.3	18.63	473.26	2.581	65.55	75.658	112.592
			11	19.46	494.33	2.182	55.42	65.237	97.084
			11.5	19.66	499.34	2.087	53.01	62.690	93.294
24	24.000	609.60	13.5	20.30	515.68	1.778	45.16	54.206	80.668
			15.5	20.78	527.80	1.548	39.33	47.731	71.032
			17	21.06	535.01	1.412	35.86	43.801	65.184
			21	21.62	549.22	1.143	29.03	35.907	53.436
			26	22.08	560.83	0.923	23.45	29.299	43.601
			32.5	22.46	570.59	0.738	18.76	23.638	35.177
			11	22.71	576.72	2.545	64.65	88.795	132.142
			11.5	22.94	582.57	2.435	61.84	85.329	126.983
			13.5	23.69	601.62	2.074	52.68	73.781	109.798
			15.5	24.24	615.76	1.806	45.88	64.967	96.682
28	28.000	711.20	17	24.57	624.18	1.647	41.84	59.618	88.722
			21	25.23	640.76	1.333	33.87	48.874	72.732
			26	25.76	654.30	1.077	27.35	39.879	59.346
			32.5	26.21	665.68	0.862	21.88	32.174	47.880
			11	24.33	617.91	2.727	69.27	101.934	151.694
			11.5	24.57	624.18	2.609	66.26	97.954	145.771
			13.5	25.38	644.60	2.222	56.44	84.697	126.043
			15.5	25.97	659.74	1.935	49.16	74.580	110.987
30	30.000	762.00	17	26.33	668.77	1.765	44.82	68.439	101.849
			21	27.03	686.53	1.429	36.29	56.105	83.494
			26	27.60	701.04	1.154	29.31	45.779	68.127
			32.5	28.08	713.23	0.923	23.45	36.934	54.965
			13.5	27.07	687.57	2.370	60.21	96.367	143.409
			15.5	27.71	703.73	2.065	52.44	84.855	126.278
32	32.000	812.80	17	28.08	713.35	1.882	47.81	77.869	115.882
			21	28.83	732.29	1.524	38.70	63.835	94.997
			26	29.44	747.78	1.231	31.26	52.086	77.513
			32.5	29.95	760.78	0.985	25.01	42.023	62.538
			15.5	31.17	791.69	2.323	58.99	107.395	159.821
			17	31.60	802.52	2.118	53.79	98.553	146.663
36	36.000	914.40	21	32.43	823.83	1.714	43.54	80.791	120.231
			26	33.12	841.25	1.385	35.17	65.922	98.102
			32.5	33.70	855.88	1.108	28.14	53.186	79.149
			15.5	36.36	923.64	2.710	68.83	146.176	217.534
			17	36.86	936.27	2.471	62.75	134.141	199.625
42	42.000	1066.80	21	37.84	961.14	2.000	50.80	109.966	163.648
			26	38.64	981.46	1.615	41.03	89.727	133.528
			32.5	39.31	998.52	1.292	32.82	72.392	107.731

(See ASTM D3035, F714 and AWWA C-901/906 for OD and wall thickness tolerances).
(Weights are calculated in accordance with PPI TR-7).

Table A-2 (cont)
PIPE WEIGHTS AND DIMENSIONS *(IPS)*
PE3408 *(BLACK)*

OD			SDR	Nominal ID		Minimum Wall		Weight	
Nominal	Actual							lb. per	kg. per
in.	in.	mm.		in.	mm.	in.	mm.	foot	meter
			7	11.25	285.64	2.286	58.06	42.786	63.673
			7.3	11.44	290.60	2.192	55.67	41.329	61.504
			9	12.30	312.48	1.778	45.16	34.598	51.487
			9.3	12.42	315.51	1.720	43.70	33.626	50.041
			11	12.97	329.55	1.455	36.95	28.994	43.149
16	16.000	406.40	11.5	13.11	332.89	1.391	35.34	27.862	41.464
			13.5	13.53	343.78	1.185	30.10	24.092	35.852
			15.5	13.85	351.86	1.032	26.22	21.214	31.570
			17	14.04	356.68	0.941	23.91	19.467	28.970
			21	14.42	366.15	0.762	19.35	15.959	23.749
			26	14.72	373.89	0.615	15.63	13.022	19.378
			7	12.65	321.35	2.571	65.31	54.151	80.586
			7.3	12.87	326.93	2.466	62.63	52.307	77.841
			9	13.84	351.54	2.000	50.80	43.788	65.164
			9.3	13.97	354.94	1.935	49.16	42.558	63.333
			11	14.60	370.75	1.636	41.56	36.696	54.610
18	18.000	457.20	11.5	14.74	374.51	1.565	39.76	35.263	52.478
			13.5	15.23	386.76	1.333	33.87	30.491	45.376
			15.5	15.58	395.85	1.161	29.50	26.849	39.955
			17	15.80	401.26	1.059	26.89	24.638	36.666
			21	16.22	411.92	0.857	21.77	20.198	30.058
			26	16.56	420.62	0.692	17.58	16.480	24.526
			32.5	16.85	427.94	0.554	14.07	13.296	19.787
			7	14.06	357.05	2.857	72.57	66.853	99.489
			7.3	14.30	363.25	2.740	69.59	64.576	96.100
			9	15.38	390.60	2.222	56.44	54.059	80.449
			9.3	15.53	394.38	2.151	54.62	52.541	78.189
			11	16.22	411.94	1.818	46.18	45.304	67.420
20	20.000	508.00	11.5	16.38	416.12	1.739	44.17	43.535	64.787
			13.5	16.92	429.73	1.481	37.63	37.643	56.019
			15.5	17.32	439.83	1.290	32.77	33.146	49.327
			17	17.55	445.84	1.176	29.88	30.418	45.266
			21	18.02	457.68	0.952	24.19	24.936	37.108
			26	18.40	467.36	0.769	19.54	20.346	30.279
			32.5	18.72	475.49	0.615	15.63	16.415	24.429
			9	16.92	429.66	2.444	62.09	65.412	97.343
			9.3	17.08	433.82	2.366	60.09	63.574	94.609
			11	17.84	453.14	2.000	50.80	54.818	81.578
			11.5	18.02	457.73	1.913	48.59	52.677	78.393
22	22.000	558.80	13.5	18.61	472.70	1.630	41.39	45.548	67.783
			15.5	19.05	483.81	1.419	36.05	40.107	59.686
			17	19.31	490.43	1.294	32.87	36.805	54.772
			21	19.82	503.45	1.048	26.61	30.172	44.901
			26	20.24	514.10	0.846	21.49	24.619	36.637
			32.5	20.59	523.04	0.677	17.19	19.863	29.559

(See ASTM D3035, F714 and AWWA C-901/906 for OD and wall thickness tolerances).
(Weights are calculated in accordance with PPI TR-7).

HYDROLOGIC EVALUATI[illegible]
LANDFILL PERFORMANCE (HE[illegible]DEL

The HELP Model was used to determine the leachate quantities for the leachate collection system as well as other useful information. The precipitation, evaporation, solar radiation, and temperature values that were used in the model were generated from default data corresponding to the Salt Lake area as designated in the HELP Model program. The climate data that was used correlated closely with average temperature and precipitation data reported in the Western Regional Climate Center database, found at www.wrcc.dri.edu. The locations used to compare were at Dugway and the Saltair Salt Plant. Some inputs for evapotranspiration and weather data were not covered in the default data. The evaporative zone depth was assumed to be 16 inches. The maximum leaf area index was assumed to be zero. These values were assumed based on the arid desert conditions that exist in this area.

The model was set up according to the preliminary designs for the layer system. From the HELP Model manual, Table 4 entitled "Default Soil, Waste, and Geosynthetic Characteristics" was used to determine which layer classification to use. The model used 6 - 9 layers depending on the phase of construction and are summarized below:

Layer	Thickness (in.)	Porosity (Vol/Vol)	Hydraulic Conductivity (cm/sec)
Erosion Protection Layer - Gravel	0 - 3	0.397	0.3
Soil Cover	0 - 24	0.473	5.2E-4
HDPE Liner	0 - 0.06	0.0	1.99E-13
Municipal Waste	0 - 2400	0.168	1.0E-3
Soil	24	0.473	5.2E-4
Geotextile	0.05	0.1	0.14
Drainage Net - Geonet	0.1	0.85	33.0
High Density Polyethylene - HDPE Liner	0.06	0.0	1.99E-13
GCL	0.25	0.75	4.99E-9

The HELP Model was run for different waste heights in order to determine the worst case condition. Once the full waste height was reached, the model was run with and without the closure cap. The results are summarized in the following table:

Model Run - Waste Height	Peak Daily Collected at Geonet (in.)	Annual Average Collected at Geonet (in.)	Annual Average Runoff (in.)
No Waste	0.13877	1.61251	0.071
10 Feet	0.21503	2.70216	0.069
50 Feet	0.20878	2.70228	0.069
100 Feet	0.24152	2.70227	0.069
200 Feet	0.22244	2.70228	0.069
Closure	0.00834	0.46316	0.142

No Waste

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.071	(0.1112)	5135.54	0.558
EVAPOTRANSPIRATION	10.998	(1.8149)	798429.81	86.687
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.61251	(0.84207)	117068.195	12.71027
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.117	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	0.006	(0.7090)	418.28	0.045

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.259	18782.0410
DRAINAGE COLLECTED FROM LAYER 4	0.13877	10074.83890
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00154
AVERAGE HEAD ON TOP OF LAYER 5	0.035	
MAXIMUM HEAD ON TOP OF LAYER 5	0.071	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.06	77015.2031
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1740	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0402	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.069	(0.1089)	5045.55	0.548
EVAPOTRANSPIRATION	9.918	(1.6315)	720081.19	78.180
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.70216	(0.94981)	196177.141	21.29925
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.170	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.001)		
CHANGE IN WATER STORAGE	-0.003	(0.5785)	-252.02	-0.027

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.258	18759.7109
DRAINAGE COLLECTED FROM LAYER 4	0.21503	15610.95510
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00206
AVERAGE HEAD ON TOP OF LAYER 5	0.055	
MAXIMUM HEAD ON TOP OF LAYER 5	0.106	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	27.2 FEET	
SNOW WATER	1.06	77015.2031

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1328
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0190

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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50'

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.069	(0.1089)	5045.55	0.548
EVAPOTRANSPIRATION	9.918	(1.6315)	720081.19	78.180
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.70227	(0.94762)	196184.625	21.30006
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.169	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.001)		
CHANGE IN WATER STORAGE	-0.004	(0.5801)	-259.50	-0.028

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.258	18759.7109
DRAINAGE COLLECTED FROM LAYER 4	0.20878	15157.25390
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00202
AVERAGE HEAD ON TOP OF LAYER 5	0.053	
MAXIMUM HEAD ON TOP OF LAYER 5	0.108	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.06	77015.2031

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1328

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0190

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.069	(0.1089)	5045.55	0.548
EVAPOTRANSPIRATION	9.918	(1.6315)	720081.19	78.180
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.70228	(0.94740)	196185.625	21.30017
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.169	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.001)		
CHANGE IN WATER STORAGE	-0.004	(0.5803)	-260.52	-0.028

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.258	18759.7109
DRAINAGE COLLECTED FROM LAYER 4	0.24152	17534.43360
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00225
AVERAGE HEAD ON TOP OF LAYER 5	0.061	
MAXIMUM HEAD ON TOP OF LAYER 5	0.121	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	10.3 FEET	
SNOW WATER	1.06	77015.2031
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.1328
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.0190

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
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200'

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.069	(0.1089)	5045.55	0.548
EVAPOTRANSPIRATION	9.918	(1.6315)	720081.19	78.180
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.70228	(0.94730)	196185.641	21.30017
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.169	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.001)		
CHANGE IN WATER STORAGE	-0.004	(0.5804)	-260.50	-0.028

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.258	18759.7109
DRAINAGE COLLECTED FROM LAYER 4	0.22244	16149.48340
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00211
AVERAGE HEAD ON TOP OF LAYER 5	0.057	
MAXIMUM HEAD ON TOP OF LAYER 5	0.109	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	31.6 FEET	
SNOW WATER	1.06	77015.2031
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1328	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0190	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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Closure

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.69	(2.174)	921052.1	100.00
RUNOFF	0.142	(0.1373)	10311.68	1.120
EVAPOTRANSPIRATION	12.058	(1.9901)	875443.69	95.048
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.01480	(0.01790)	1074.828	0.11670
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.46317	(0.43227)	33626.137	3.65084
AVERAGE HEAD ON TOP OF LAYER 3	1.130	(1.368)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.46316	(0.44777)	33625.562	3.65078
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.012	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.008	(0.9827)	596.26	0.065

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	113255.992
RUNOFF	0.344	24941.7246
DRAINAGE COLLECTED FROM LAYER 2	0.00038	27.51882
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.008502	617.27661
AVERAGE HEAD ON TOP OF LAYER 3	10.570	
MAXIMUM HEAD ON TOP OF LAYER 3	20.450	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	123.9 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00834	605.28369
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 8	0.001	
MAXIMUM HEAD ON TOP OF LAYER 8	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.06	77015.2031
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.2673
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.0869

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

TECHNICAL NOTE ON USING HELP MODEL (VER. 3.07)

I: INPUT STEPS GUIDE

The purpose of this document is to help the users of HELP Model through the input procedures, and interpretation of the output results . All information contained herein are from HELP "User's Guide" and "Engineering Documentation" for version 3. Included is a step-by-step example, which is a part of the GRI report # 19, page 34- 37 (leachate collection system).

INSTALLATION NOTE

You can download the latest version of HELP Model 3.07 from the following web-site address: http://www.wes.army.mil/el/elmodels/index.html. You will save the downloaded file (zhelp3w.exe or zhelp3p.exe) onto a temporary subdirectory, after you execute the file it will be self extracted into some files needed for the setup. From the files that have been self extracted, you run the setup file follow the steps that will show on the screen.

Whether you download HELP Model program from the internet or install it from a floppy, the files should be installed (or copied) in a subdirectory directly under the root, i.e. C:\ or D:\. The executable file is called "Help3.bat".

INPUT STEPS

1. Weather Data

From the main menu you choose option 1 "**Enter/ Edit Weather Data**", this will prompt you to another screen with the following four options:

Evapotranspiration; Precipitation; Temperature; and Solar radiation

For each you hit "PgDn" to start new file, or "F4" to choose from a list of saved files. Below is a description of the input data required for each of the four weather selections.

1.1 <u>Evapotranspiration</u>

Evapotranspiration is the first weather option the program is going to prompt you for if you are starting a new project. However, if you're editing an existing project you'll be prompted to the screen corresponding to your selection of either of the four weather data.

a) Units: with up or down arrows you select either 1 Customary (English), or 2 Metric. In the current example we selected **Metric.**

b) City: If you're going to select **default** option, you hit "F5" to select a "State" first and then a "City" that is closest to the landfill location, then all the corresponding required data will be filled except for the following two data:

"**Evaporative Zone Depth**" in centimeters which is at least equal to the expected average depth of root penetration. To the right of the screen a table with three columns will appear that indicates the input value, you choose a value depending on the condition of vegetation expected.

Bare	Fair	Excellent
25	55	101

In our example we'll select **Texas, Austin, 25 cm** (for no vegetation)

"**Leaf Area Index**" (LAI), LAI is a dimensionless ratio of the leaf area that is actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. Below is a table that lists the LAI values for different conditions of vegetation.

Bare	Poor Stand of Grass	Fair Stand of Grass	Good Stand of Grass	Excellent Stand of Grass
0.0	1.0	2.0	3.5	5.0

In our example we'll choose **0.0** for no vegetation condition.

If you're going to select the **manual** option, in addition to the above two parameters you'll be asked to input the following parameters: location (city and state), dates of starting and ending the growing season, normal average annual wind speed, and Normal average quarterly relative humidity. The last three data are available from "Climatic Atlas of the United States" (NOAA, 1974)

1.2 Precipitation, Temperature, Solar Radiation

The input options for the above three weather data are: **Synthetic, Create/Edit, NOAA tape, Climatedata, ASCII file, HELP Version 2, and Canadian Climatological**. Only Precipitation has an extra option which is **Default**. Below is a description of the input options:

Default (Precipitation only): The user may select any of the stored 102 cities for which the historical precipitation data are recorded during 5 years from 1974 to 1978. In the current example this option is chosen and the city of **San Antonio, Texas** is selected.

Synthetic: the program will generate from 1 to 100 years of daily Precipitation, Temperature, or Solar Radiation data stochastically for the selected location using a synthetic weather generator. The user may enter normal mean monthly precipitation values for the location to improve the statistical characteristics of the resulted daily values. For that option user needs to specify a location from 139 stored cities, number of years of data to be generated, and normal mean monthly value (optional).
For the current example the synthetic option is chosen for both temperature and solar radiation data where the city of **Austin, Texas**, and **5** years are selected.

Create/Edit, NOAA tape, Climatedata, ASCII file, HELP Version 2, and Canadian Climatological: all of these 6 options require the user to input the location (city and state), and the corresponding daily precipitation, temperature, or solar radiation data stored in a saved file(s) name, the format of the file(s) differs from option to the other. All options accept customary or metric units.

After completing entering the weather data input, you hit "F10" to end and save by typing the path and the name of each of the four saved files. The files will take automatically a default extensions as: D4; D7; D13; and D11 for Precipitation; Temperature; Solar radiation; and Evapotranspiration respectively (do not attempt to change the default extensions). After saving the files, you'll be prompted to the main menu screen. The program will prompt you to a warning screen if one or more of the data is missed or incorrect.

2. Soil Data

From the main menu you choose option 2 "**Enter/ Edit Soil Data**", this will prompt you to another screen where you either hit "PgDn" to start new file, or "F4" to choose from a list of saved files. Below is a description of the input soil data:

2.1 Initial Information

The first screen of soil data input contains the following required information:

Unit System: on the same screen you are prompted to select a unit system, in the current example we selected **Metric**, Then you're prompted to another screen where you input;

Project Title: in the current example: "**Example in GRI Report # 19**"

Landfill Area: in the current example: **4 hectares**

Percent of landfill where runoff is possible: in the current example **100%**

Method of initialization of moisture storage: you have two options: 1) to choose to enter the initial moisture content for the soil layers in the analyzed profile as per the available soil information, and then at the following screen you'll input the corresponding values. 2) to let the program initialize the moisture content to the near steady-state condition, **option (2)** is selected in the current example.

Initial Snow/Water Storage: this piece of information is optional and needed when moisture storage is user-defined.

2.2 Layers Information

The second, third, and fourth screens contain the layers information as follows:

2.2.1 General Soil Information

Layer Type: four types of layers are supported by HELP model; 1)vertical percolation, 2) lateral drainage, 3) barrier soil liner, and 4) geomembrane liner

Layer thickness: in customary or Metric systems

Soil Texture: the soil texture information contains four properties;

- Porosity (vol/vol)
- Field Capacity (vol/vol)
- Witlting point (vol/vol), and
- Saturated hydraulic conductivity (cm/sec)

The user has the option to select from a 42 default soil/ material textures, select from user-built soil texture library where the properties will be automatically assigned, or to enter the above information manually. To learn more about the above properties refer to section "3.5 Soil Characteristics" of HELP Model User's Guide.

Initial moisture storage: vol/vol, optional if you choose option (1) of "Method of initialization of moisture storage" in section 2.1.

Rate of subsurface inflow to layer: optional, customary or Metric unit systems (mm or inch/year).

2.2.2 Layer Specific Information

The four types of layers that are supported by HELP model are explained below:

Vertical Percolation Layer: waste and vegetation support layers are examples of vertical percolation layer. The downward flow in the vertical percolation layer is modeled by the unsaturated vertical gravity drainage. The upward flux due to evapotranspiration is modeled as an extraction.

Lateral Drainage Layer: the lateral drainage layer is designed to promote drainage laterally to a collection and removal system. The vertical flow in this layer is modeled as in the vertical percolation layer, however, a saturated lateral drainage is also allowed. In addition to the soil data in section 2.2.1, the following information are also required to model the lateral drainage layer:

- Max drainage length: customary or Metric. The horizontal projection of the slope, rather than the distance along the slope.
- Drain slope: percent. From 0 to 50 percent

- Percentage of recirculated to collected leachate. From 0 to 100%
- Layer No. to receive the recirculated leachate. Vertical percolation or lateral drainage. Layer number.

Barrier soil liners: are intended to restrict vertical drainage/ leakage/ percolation. These layers should have significantly lower hydraulic conductivity than the other layers. The barrier soil layer is assumed to be saturated all time but leak only when there is a positive head on the top surface of the liner. HELP model allows only downward saturated flow through the barrier soil layer, thus any water moving into the liner will eventually percolate through it. Evapotranspiration and lateral drainage are not permitted.

Geomembrane liners: are virtually impermeable synthetic membranes that reduce the area of vertical drainage/ leakage/ percolation to a very small fraction of the area locatednear manufacturing flaws and installation defects. Also a small quantity of vapor transport is modeled by specifying the vapor diffusivity of the geomembrane liner. In addition to data listed in section 2.2.1, the following information is required:

- Pinhole density: (#/acre or hectare). Defects of a diameter equal or smaller than the membrane thickness (estimated as 1 mm in diameter). Typical geomembranes may have from 0.5 to 1 pinhole per acre (1 to 2 per hectare).

- Installation defects density: (#/acre or hectare). Defects of a diameter greater than the membrane thickness (estimated as 1 cm^2 in area).

Installation Quality	Defect Density (#/acre)	Frequency (%)
Excellent	Up to 1	10
Good	1 to 4	40
Fair	4 to 10	40
Poor	10 to 20 (old landfills)	10

- Placement quality: addresses the quality of contact between geomembrane and the underneath soil that limits the drainage rate. The table below explains the 6 cases supported by HELP model:

1. Perfect	Assumes perfect, (no gap, "sprayed-on" seal)
2. Excellent	Assumes exceptional contact (typically achievable only in the lab)
3. Good	Assumes good field installation with well-prepared, smooth soil surface and geomembrane wrinkle control
4. Poor	Assumes poor field installation with a less well-prepared soil surface and/ or geomembrane wrinkling control
5. Worst Case	Assumes that contact between geomembrane and the underneath does not limit drainage rate

6. Separating Geotextile — Assumes leakage spreading and rate is controlled by the in-plane transmissivity of the geotextile separating the geomemebrane and the adjacent soil layer. This quality does not apply to GCL where bentonite swells upon wetting and extrudes into the geotextile significantly reducing its ability to spread the leakage.

- Saturated hydraulic conductivity: (vapor diffusivity), cm/sec
- Geotextile in-plane transmissivity, cm^2/sec (optional when placed with geomembrane)

In the current example two layers are simulated, the following is the information required from the user as input. Other information is set up as default values corresponding to the layer's texture number:

1) Lateral drainage layer

   - Type 2
   - thickness 45 cm
   - texture number 21
   - slope length 10 m
   - slope: 33%
   - percent of recirculated leachate; zero%

2) Geomembrane liner

   - Type 4
   - thickness 0.15 cm
   - texture number 35
   - zero pinholes and zero installation defects
   - placement quality: 1 (perfect)

2.3 Site Characteristics

The third screen contains the runoff curve number information, the user has three options to input the SCS runoff curve number: 1) defined by the user, 2) defined by the user and modified

by HELP model for slope surface and length, and 3) computed by HELP model based on top layer texture, slope length and slope.
In the current example **option 3** is selected and the corresponding slope %, slope length, soil texture and vegetation conditions (1: bare, 2:poor, 3: fair, 4:good, 5: excellent stand of grass) are input as in the previous step for the top layer (drainage layer). The SCS runoff curve number calculated by HELP model is **75.9**.

After completing entering the soil data input, you hit "F10" to end and save by typing the path and name of the file, the file will take automatically a default extension as: D10 (do not attempt to change the default extensions). After saving the file, you'll be prompted to the main menu screen. The program will prompt you to a warning screen if one or more of the data is missed or incorrect.

3. Execution, Viewing and Printing Results

From the main menu you choose option 3 "**Execute Simulation**" which will prompt you to a screen where you type the five files' names which contain weather and soil data information. Then to another screen where the program asks for the unit system wanted for the output (regardless of the system used in the input data), number of years during which the output is generated, and the intervals of the generated output; annual, monthly, or daily. The program will take few minuets (variable depending on your computer speed) to execute the project information, then it'll prompt to the main menu. To view or to print* the out put you choose either option 4 "**View Results**", or option 5 "**Print Results**".

A printout of the example discussed above is included.

*Since HELP model is DOS operated program, a conflict in the printing command may occur. It's recommended to open and print the output file "**filename.out**" through the program "**Notepad**" found in your Windows 95 system under: "start/programs/accessories/notepad".

4. Flux Calculations

Referring to the output table: "Peak Daily Values for Years 1974 Through 1978", drainage collected from layer 1= 61.12513 mm (0.061 m/day)

Hourly Flux (m^3/hr)/ width (m) = Depth of Liquid Collected Daily (m/day) x Slope length (m) / 24 (hr/day)
=(0.061)*(10)/24 = 0.025 m^3/hr-m width

II: DRAINAGE GEOCOMPOSITE INPUT DATA

As discussed in section I, the input data for the lateral drainage Layer (Layer Type 2) could be divided into two categories; 1) project specific , and 2) product specific. The properties under the project specific category are listed on page 4 of section I. This section discusses the product specific properties for the lateral drainage layer with an emphasis on geosynthetic drainage geocomposites. In general, it should be noted that unlike the conventional soil drainage layer (sand or aggregate), the physical and hydraulic properties of geosynthetic materials are highly dependent on project's design criteria, such as anticipated normal load, hydraulic gradient, and boundary conditions. The five required properties for the drainage layer are as follows:

1. **Thickness (mm, inch)**

The layer thickness determined at the anticipated normal load.

2. **Porosity (vol/vol)**

The volume of space/total volume.

3. **Field Capacity (vol/vol)**

Field capacity as defined in HELP Model is the amount of water that the product will accept before gravity flow could commence in the layer.

4. **Wilting Point (vol/vol)**

Wilting point by definition is the maximum amount of moisture in the material that can not be drawn by plants

5. **Saturated Hydraulic Conductivity (cm/sec)**

The saturated hydraulic conductivity of the geonets are determined by dividing the transmissivity measured under the required design and field conditions by the corresponding thickness of the geonet.

The table below presents the above discussed properties for two of Tenax's geocomposites; Tenflow and Tendrain used typically for landfill capping and lining applications respectively.

Tenax's Lateral Drainage Layer Input Data for HELP Model

Geonet Type	Thickness* (mm/mils)	Porosity (vol/vol)	Field Capacity+ (vol/vol)	Wilting Point+ (vol/vol)	Saturated Hydraulic Conductivity++ (cm/sec)
Tenflow	7.30/ 287	0.86	0.01	0.005	15.8
Tendrain	5.14/ 202	0.70	0.01	0.005	12.4

*Measured at anticipated stress level of 1,000 psf for Tenflow, and 15,000 for Tendrain (geonet only)
+ Per HELP Model default value for drainage geonets
++Determining the Design Hydraulic Conductivity for Drainage Geocomposites.

Equations:

$$T_{all} = \frac{T_{ult}}{RFin*RFcr*RFcc*RFbc} \qquad (1)$$

Where, T_{all} = allowable Transmissivity [cm^2/s]

T_{ult} = ultimate Transmissivity measured in the lab [cm^2/s]

RF_{in} = reduction factor for intrusion of adjacent geotextile

RF_{cr} = reduction factor for creep deformation

RF_{cc} = reduction factor for chemical clogging

RF_{bc} = reduction factor for biological clogging

$$T_{dsg} = \frac{T_{all}}{FS} \qquad (2)$$

Where, T_{dsg} = design Transmissivity used in calculations [cm^2/s]

FS = overall factor of safety

$$T_{dsg} = k_{dsg}*t_{dsg} \qquad (3)$$

Where, k_{dsg} = design hydraulic conductivity used in calculations [cm^2/s]

t_{dsg} = design thickness used in calculations [cm]

Solution:

Landfill Final Closure:

1) Estimated design load on landfill foundation = 1,000 psf

2) Ultimate Transmissivity = T_{ult} = 4.0 * 10E-3 m^2/sec = 40 cm^2/s

(geocomposite tested in soil boundary condition under 1,000 psf, a hydraulic gradient of 0.33, and a seating period of 100 hours)

3) Using Table 1 for typical values of reduction factors, *Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International*: RFin = 1.1, RFcc = 1.1, RFbc = 1.4

4) Using RFcr = 1.02 (determined value for Tenflow)

5) FS = 2.0 (state of practice typical value)

6) **t_{dsg} = 0.730 cm (0.287 inches)**

Substituting in Equation (1): T_{all} = 23.1 cm^2/sec

Substituting in Equation (2): T_{dsg} = 11.6 cm^2/sec

Substituting in Equation (3): k_{dsg} = **15.8 cm/sec**

Landfill Liner Prior to Final Closure:

1) Estimated design load on landfill foundation = 15,000 psf

2) Ultimate Transmissivity = T_{ult} = 5.0 * 10E-3 m^2/sec = 50 cm^2/s

(geocomposite tested in soil boundary condition under 15,000 psf, a hydraulic gradient of 0.02, and a seating period of 100 hours)

3) Using Table 1 for typical values of reduction factors, *Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International*: RFin = 1.2, RFcc = 1.75, RFbc = 1.75

4) Using RFcr = 1.07 (determined value for Tendrain)

5) FS = 2.0 (state of practice typical value)

6) t_{dsg} = **0.514 cm (0.202 inches)**

Substituting in Equation (1): T_{all} = 12.7 cm^2/sec

Substituting in Equation (2): T_{dsg} = 6.4 cm^2/sec

Substituting in Equation (3): k_{dsg} = **12.4 cm/sec**

Please note that the above calculations were done assuming typical information for the design requirements of a landfill liner and a landfill cap systems, as well as product design data for specific drainage geocomposites. The design engineer should implement the design data that are representative to the project in design and the considered products.

TABLE 4. DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity	
HELP	USDA	USCS	vol/vol	vol/vol	vol/vol	cm/sec	
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}	
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}	
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}	
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}	
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}	
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}	
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}	
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}	
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}	
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}	
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}	
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}	
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}	
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}	
15	C	CH	0.475	0.378	0.265	1.7×10^{-5}	
16	Barrier Soil		0.427	0.418	0.367	1.0×10^{-7}	
17	Bentonite Mat (0.6 cm)		0.750	0.747	0.400	3.0×10^{-9}	GCL 1@ 5×10^{-9}
18	Municipal Waste (900 lb/yd^3 or 312 kg/m^3)		0.671	0.292	0.077	1.0×10^{-3}	Waste
19	Municipal Waste (channeling and dead zones)		0.168	0.073	0.019	1.0×10^{-3}	
20	Drainage Net (0.5 cm)		0.850	0.010	0.005	$1.0 \times 10^{+1}$	Geonet
21	Gravel		0.397	0.032	0.013	3.0×10^{-1}	
22	L*	ML	0.419	0.307	0.180	1.9×10^{-5}	
23	SiL*	ML	0.461	0.360	0.203	9.0×10^{-6}	
24	SCL*	SC	0.365	0.305	0.202	2.7×10^{-6}	
25	CL*	CL	0.437	0.373	0.266	3.6×10^{-6}	
26	SiCL*	CL	0.445	0.393	0.277	1.9×10^{-6}	
27	SC*	SC	0.400	0.366	0.288	7.8×10^{-7}	
28	SiC*	CH	0.452	0.411	0.311	1.2×10^{-6}	
29	C*	CH	0.451	0.419	0.332	6.8×10^{-7}	
30	Coal-Burning Electric Plant Fly Ash*		0.541	0.187	0.047	5.0×10^{-5}	
31	Coal-Burning Electric Plant Bottom Ash*		0.578	0.076	0.025	4.1×10^{-3}	
32	Municipal Incinerator Fly Ash*		0.450	0.116	0.049	1.0×10^{-2}	
33	Fine Copper Slag*		0.375	0.055	0.020	4.1×10^{-2}	
34	Drainage Net (0.6 cm)		0.850	0.010	0.005	3.3×10^{-1}	Geonet

* Moderately Compacted .635 cm (Continued)

TABLE 4 (continued). DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification		Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	Geomembrane Material	vol/vol	vol/vol	vol/vol	cm/sec
35	High Density Polyethylene (HDPE)				2.0×10^{-13}
36	Low Density Polyethylene (LDPE)				4.0×10^{-13}
37	Polyvinyl Chloride (PVC)				2.0×10^{-11}
38	Butyl Rubber				1.0×10^{-12}
39	Chlorinated Polyethylene (CPE)				4.0×10^{-12}
40	Hypalon or Chlorosulfonated Polyethylene (CSPE)				3.0×10^{-12}
41	Ethylene-Propylene Diene Monomer (EPDM)				2.0×10^{-12}
42	Neoprene				3.0×10^{-12}

Membrane

(concluded)

user-defined soil option accepts non-default soil characteristics for layers assigned soil type numbers greater than 42. This is especially convenient for specifying characteristics of waste layers. User-specified soil characteristics can be assigned any soil type number greater than 42.

When a default soil type is used to describe the top soil layer, the program adjusts the saturated hydraulic conductivities of the soils in the top half of the evaporative zone for the effects of root channels. The saturated hydraulic conductivity value is multiplied by an empirical factor that is computed as a function of the user-specified maximum leaf area index. Example values of this factor are 1.0 for a maximum LAI of 0 (bare ground), 1.8 for a maximum LAI of 1 (poor stand of grass), 3.0 for a maximum LAI of 2 (fair stand of grass), 4.2 for a maximum LAI of 3.3 (good stand of grass) and 5.0 for a maximum LAI of 5 (excellent stand of grass).

The manual option requires values for porosity, field capacity, wilting point, and saturated hydraulic conductivity. These and related soil properties are defined below.

Soil Water Storage (Volumetric Content): the ratio of the volume of water in a soil to the total volume occupied by the soil, water and voids.

Total Porosity: the soil water storage/volumetric content at saturation (fraction of total volume).

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.84902°N 112.75142°W 4271 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003

Extracted: Mon Aug 9 2004

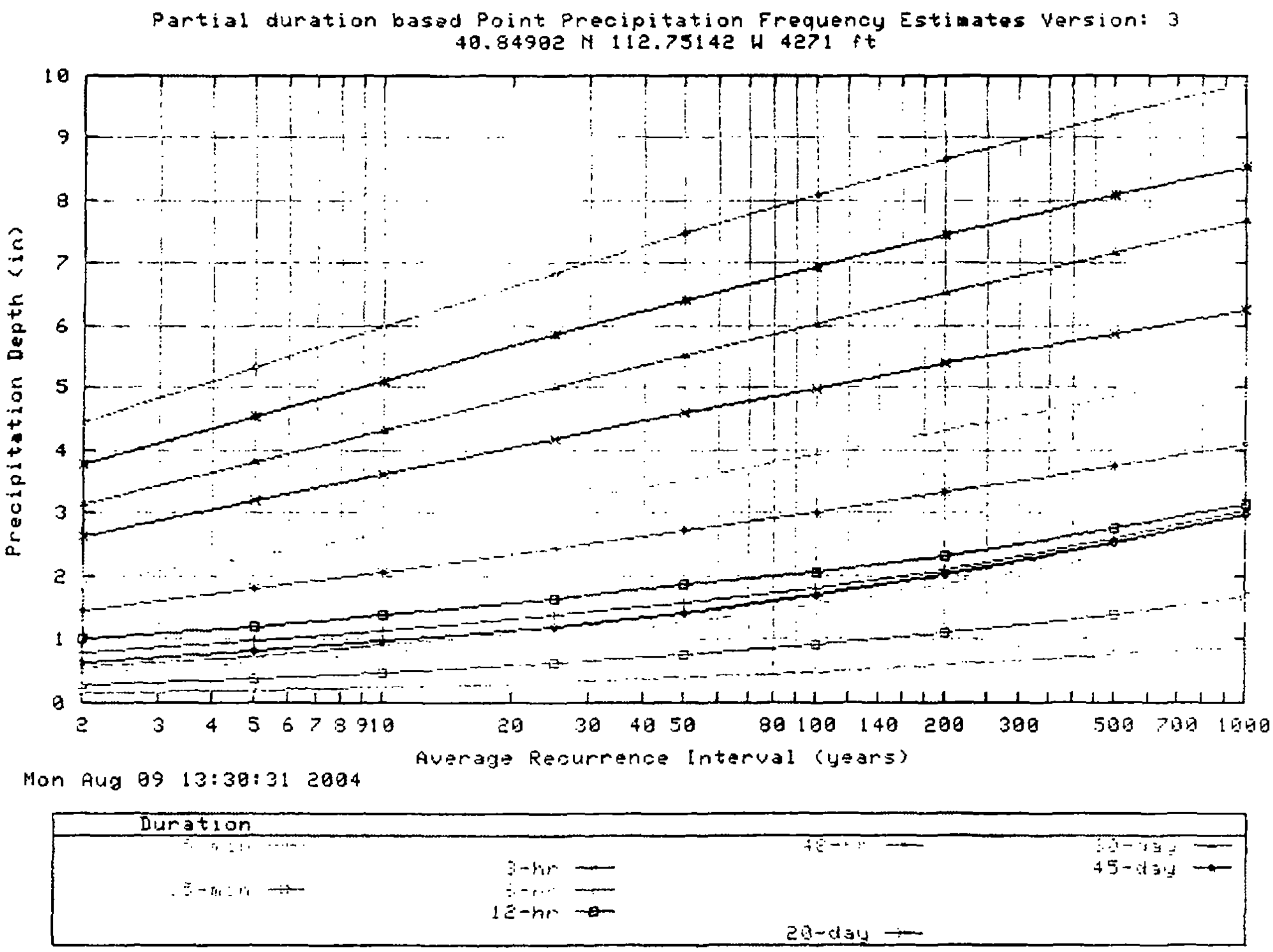
Confidence Limits | Seasonality | Location Maps | Other Info. | Grids | Maps | Help | Docs | U.S. M

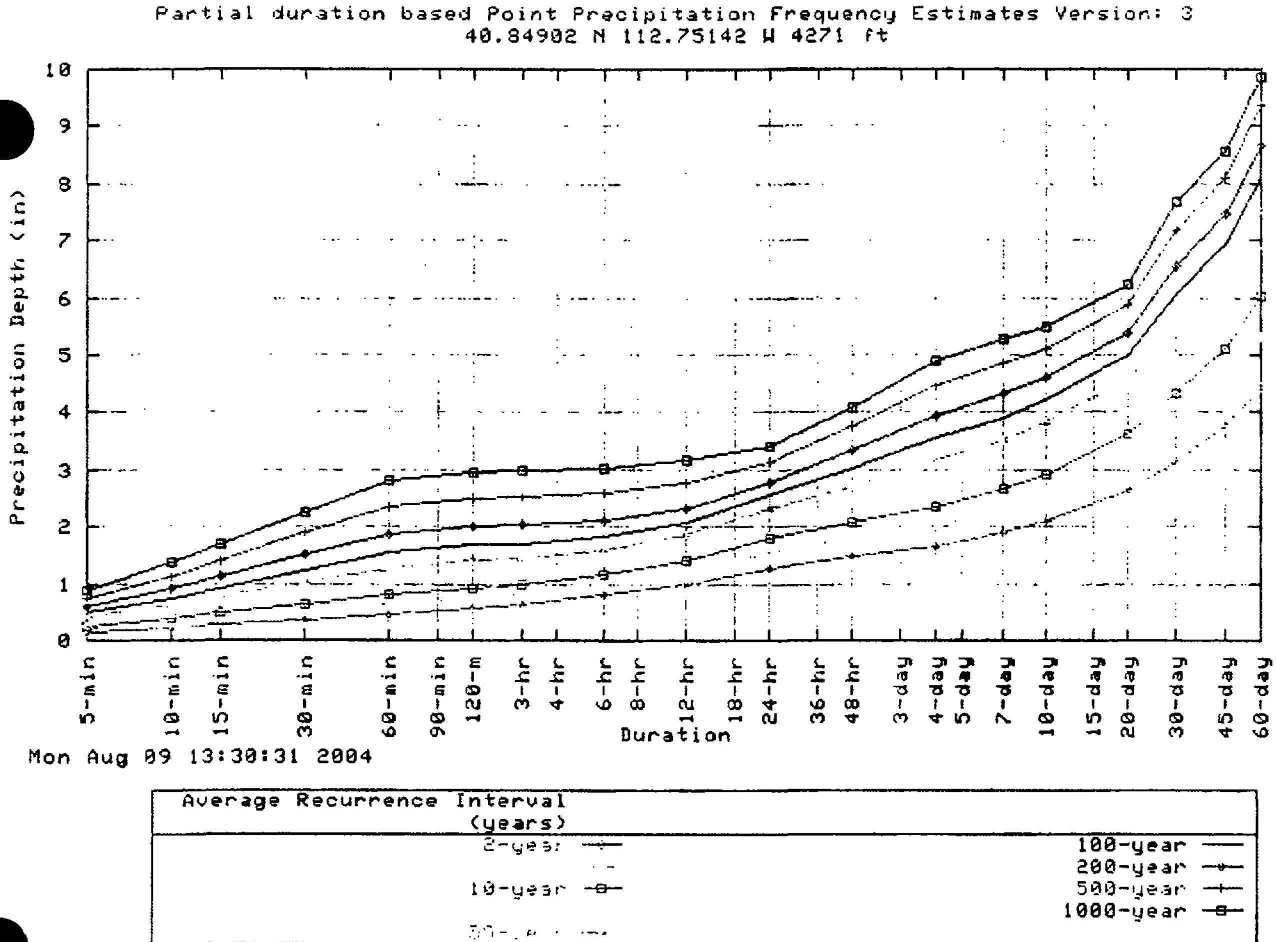
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.14	0.22	0.27	0.37	0.46	0.56	0.64	0.81	1.00	1.28	1.47	1.66	1.89	2.10	2.64	3.13	3.77	4.44
5	0.20	0.31	0.38	0.51	0.63	0.74	0.82	0.99	1.22	1.56	1.80	2.05	2.32	2.56	3.20	3.80	4.53	5.33
10	0.25	0.38	0.48	0.64	0.79	0.91	0.97	1.15	1.40	1.78	2.06	2.37	2.68	2.94	3.63	4.32	5.12	6.01
25	0.33	0.51	0.63	0.85	1.05	1.17	1.22	1.39	1.66	2.09	2.44	2.82	3.16	3.44	4.18	5.01	5.86	6.87
50	0.41	0.62	0.77	1.03	1.28	1.41	1.44	1.58	1.86	2.32	2.73	3.17	3.54	3.82	4.59	5.53	6.41	7.49
100	0.49	0.75	0.93	1.25	1.55	1.68	1.71	1.81	2.07	2.56	3.03	3.55	3.92	4.21	5.00	6.04	6.95	8.09
200	0.59	0.90	1.12	1.50	1.86	2.00	2.02	2.11	2.32	2.79	3.34	3.93	4.32	4.60	5.39	6.54	7.45	8.66
500	0.75	1.14	1.41	1.90	2.35	2.51	2.53	2.60	2.78	3.12	3.76	4.47	4.86	5.12	5.89	7.19	8.09	9.37
1000	0.89	1.36	1.68	2.26	2.80	2.96	2.98	3.04	3.15	3.40	4.09	4.89	5.28	5.51	6.25	7.67	8.55	9.88

Text version of table

* These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.





Confidence Limits -

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																	
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.17	0.26	0.32	0.42	0.53	0.64	0.71	0.88	1.09	1.42	1.63	1.84	2.10	2.33	2.91	3.46	4.15	4.90
5	0.23	0.35	0.44	0.59	0.73	0.84	0.91	1.08	1.32	1.74	2.00	2.27	2.58	2.85	3.53	4.21	5.00	5.89
10	0.29	0.44	0.55	0.74	0.91	1.02	1.08	1.25	1.52	1.98	2.29	2.62	2.97	3.26	4.00	4.79	5.63	6.63
25	0.38	0.58	0.72	0.98	1.21	1.32	1.37	1.52	1.80	2.32	2.71	3.12	3.51	3.82	4.62	5.55	6.46	7.58
50	0.47	0.72	0.89	1.20	1.48	1.60	1.64	1.76	2.04	2.58	3.04	3.51	3.92	4.25	5.07	6.12	7.07	8.28
100	0.58	0.88	1.09	1.47	1.82	1.94	1.98	2.07	2.32	2.85	3.38	3.93	4.36	4.69	5.53	6.70	7.66	8.96
200	0.71	1.07	1.33	1.79	2.22	2.35	2.39	2.47	2.64	3.12	3.74	4.38	4.81	5.14	5.97	7.27	8.24	9.61
500	0.91	1.39	1.72	2.32	2.87	3.02	3.06	3.13	3.22	3.51	4.23	5.00	5.45	5.76	6.55	8.05	8.97	10.45
1000	1.11	1.68	2.09	2.81	3.48	3.63	3.68	3.75	3.80	3.85	4.62	5.50	5.94	6.22	6.99	8.62	9.52	11.04

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

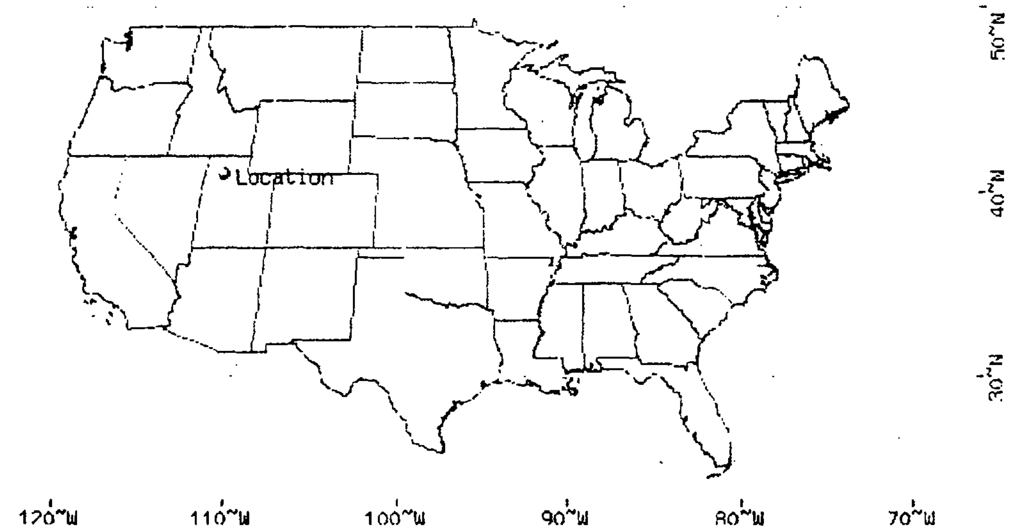
* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																	
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day

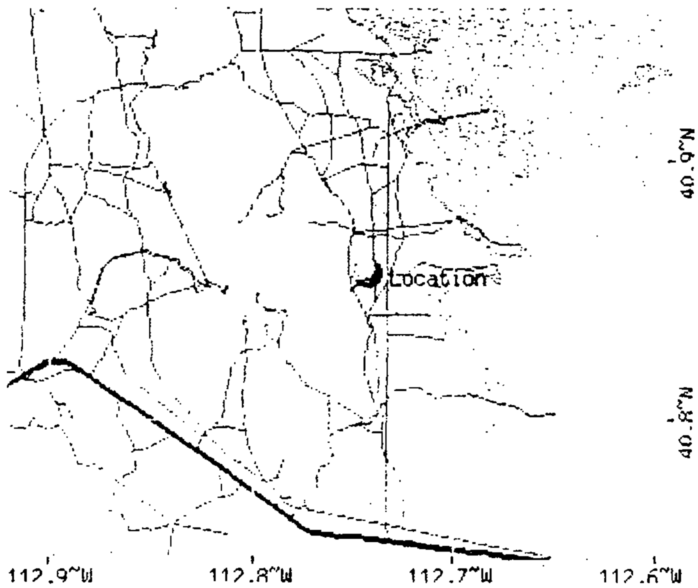
2	0.13	0.19	0.24	0.32	0.40	0.51	0.58	0.75	0.93	1.16	1.33	1.51	1.72	1.90	2.39	2.83	3.44	4.02
5	0.18	0.27	0.33	0.45	0.55	0.67	0.74	0.91	1.13	1.41	1.63	1.86	2.10	2.31	2.90	3.45	4.13	4.83
10	0.22	0.33	0.41	0.56	0.69	0.80	0.88	1.06	1.29	1.61	1.86	2.15	2.42	2.65	3.29	3.91	4.65	5.43
25	0.28	0.43	0.53	0.72	0.89	1.01	1.08	1.26	1.51	1.88	2.19	2.54	2.85	3.08	3.78	4.51	5.32	6.19
50	0.34	0.51	0.63	0.85	1.06	1.19	1.24	1.42	1.68	2.07	2.44	2.85	3.16	3.42	4.13	4.96	5.80	6.73
100	0.40	0.60	0.75	1.01	1.25	1.38	1.44	1.59	1.85	2.27	2.69	3.15	3.49	3.74	4.49	5.40	6.26	7.24
200	0.46	0.70	0.87	1.17	1.45	1.59	1.67	1.81	2.04	2.46	2.95	3.47	3.82	4.07	4.81	5.82	6.69	7.73
500	0.56	0.85	1.05	1.41	1.75	1.90	1.99	2.17	2.37	2.72	3.28	3.89	4.25	4.47	5.23	6.34	7.21	8.31
1000	0.64	0.97	1.20	1.61	2.00	2.15	2.27	2.48	2.64	2.94	3.53	4.21	4.57	4.78	5.52	6.72	7.58	8.71

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -





These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read disclaimer for more information.

LEGEND

State, County, Indian Resv, Lake/Pond/Ocean, Street, Expressway, Highway, Connector, Stream, Military Area, National Park, Other Park, City, County

Scale 1:228583 0 2 4 6 8 mi; 0 2 4 6 8 10 km

*average--true scale depends on monitor resolution

Other Maps/Photographs -

View USGS Digital Raster Graphic (DRG) covering this location from TerraServer; **USGS Aerial Photograph** may also be available from this site. A DRG is a digitized version of a USGS topographic map. Visit the USGS Digital Backyard for more infonnation.

Watershed/Stream Flow Information -

d the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to our documentation.

Using the National Climatic Data Center's (NCDC) station search engine, locate other climate stations within:

+/-30 minutes ...OR... +/-1 degree of this location (40.84902/-112.75142). Digital ASCII data can be obtained directly from NCDC.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the Western Regional Climate Center's state-specific SNOTEL station maps.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910

(301) 713-1669
uestions?: HDSC.Questions@noaa.gov

aimer

SALTAIR SALT PLANT, UTAH (427578)

›riod of Record Monthly Climate Summary

Period of Record : 5/ 7/1956 to 8/31/1991

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.9	40.7	49.0	58.3	68.8	80.3	89.6	87.2	76.4	62.3	48.8	37.2	61.0
Average Min. Temperature (F)	17.8	23.3	31.1	38.8	47.1	56.1	63.9	61.6	51.1	39.8	30.1	21.6	40.2
Average Total Precipitation (in.)	0.71	0.75	1.31	1.73	1.70	1.02	0.68	0.78	1.21	1.32	1.11	0.82	13.15
Average Total SnowFall (in.)	5.6	3.7	3.4	1.4	0.1	0.0	0.0	0.0	0.0	0.9	2.2	6.2	23.6
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	1	0

Percent of possible observations for period of record.
Max. Temp.: 87.2% Min. Temp.: 87.9% Precipitation: 99.7% Snowfall: 96.8% Snow Depth: 94.8%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

DUGWAY, UTAH (422257)

Period of Record Monthly Climate Summary

Period of Record : 9/21/1950 to 3/31/2004

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	38.2	45.0	54.1	63.1	73.8	85.1	94.7	92.1	81.2	67.2	50.6	39.5	65.4
Average Min. Temperature (F)	16.0	22.5	28.5	35.4	44.1	53.1	61.2	59.4	48.1	35.8	25.7	17.7	37.3
Average Total Precipitation (in.)	0.55	0.62	0.75	0.81	0.98	0.55	0.50	0.59	0.59	0.70	0.56	0.56	7.74
Average Total SnowFall (in.)	3.8	3.0	2.3	0.8	0.2	0.0	0.0	0.0	0.0	0.1	1.7	3.5	15.5
Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 97.8% Min. Temp.: 97.8% Precipitation: 97.6% Snowfall: 96.8% Snow Depth: 89.4%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

LEACHATE COLLECTION S

1. Determine the required geonet transmissivity to provide sufficient capacity to conduct the leachate to the leachate collection pipes.

a. Bearing pressure over the geonet.

The Normal Bearing Pressure (P'):

240' Waste at 80 pcf	=	19,200 psf
2 + 2' Soil Protective Cover at 120 pcf	=	490 psf
	=	19,690 psf (use 19,700 psf)
N TOTAL	=	136.8 psi

b. Required Geonet Capacity

the geonet will be required to conduct the greatest amount of water at the low side of the planar slopes just prior to discharging leachate into the leachate collection pipes. The boundary conditions for the geonet (from top to bottom) are:

Closure and Waste Loading
2' protective soil cover comprised of fine sands and silts
8 oz. Non-woven geotextile filter fabric
Geonet
60-mil HDPE geomembrane liner

The longest one-foot wide flow path within the geonet is approximately 140 feet along the resultant slope of the wider planar surfaces. The leachate rate from this flow path length is present below.

The peak daily leachate rate to the geonet drainage layer is 0.242 inches/day based on the HELP model output. The peak daily flow from the longest flow path is calculated below.

$$q_{leachate} = (140\text{ ft})(0.242\text{ inches/day})(1\text{ foot}/\ 12\text{ inches})$$
$$q_{leachate} = 2.82\text{ ft}^3/\text{ft-day}$$

The minimum slope for the planar surfaces for the geonet after applying the projected differential settlement is 2.0%. A steeper slope will provide a more conservative design.

The required transmissivity for the geonet is given by $q_{req'd}$ and is related to the leachate rate $q_{leachate}$ by applying necessary safety factors. The combination of all the necessary safety factors is a resulting safety factor. Therefore,

$$q_{req'd} = q_{leachate} \times SF_{RES}$$

"Designing with Geosynthetics" by Robert Koerner provides recommended safety factors in the design of geonets as follows:

SF_{IN} = Safety factor for intrusion of adjacent geosynthetic materials into the geonet (1.5)
SF_{CR} = Safety factor for creep deformation of the geonet (1.5)
SF_{BCC} = Safety factor for biological and chemical clogging (2.0)

In addition to the safety factors presented above, Koerner recommends a safety factor for the design-by-function concept (SF_{DBF} = 1.5) which is a ratio of the allowable test value for the geonet to the required design value.

Combining all of the safety factors presented yields a resulting safety factor of:

$SF_{RES} = 1.5 \times 1.5 \times 2.0 \times 1.5 = 6.75$

Using the information presented above, the required geonet transmissivity is:

$(2.82)(6.75) = (\Theta\ m^2/sec)(10.7639\ ft^2/m^2)(86400\ sec/day)(0.02)$

Where Θ is the hydraulic transmissivity of the drainage net in m^2/sec

Therefore, $\Theta = 1.023 \times 10^{-3}\ m^2/sec$

Therefore the drainage net should have be tested to provide the required hydraulic transmissivity at the loading and boundary conditions provided.

c. Results of Help Model

Results of the HELP Model

Scenario	Peak Daily Leachate Drainage Geonet (in.)	Average Annual Leachate Drainage Geonet (in.)
No Waste	0.13877	1.61251
10' Waste	0.21503	2.70216
50' Waste	0.20878	2.70228
100' Waste	0.24152	2.70227
200' Waste	0.22244	2.70228

2. Determine the required capacity and diameter for the drainage pipe extending up the valleys in the floor formed by the planar floor surfaces.

a. The widest drainage area contributing leachate to the leachate collection pipes is 280 feet along the center pipe extending west from the center of the sumps. Determine the maximum length of various pipe diameters that can be placed along the 280 feet wide section of the floor with adequately capacity to convey the peak day leachate volume of 0.242 inch per day.

Area = 280 ft^2/ft of pipe length
Q = (280 ft^2)(0.242 in/day)(1 ft/12in)
Q = 5.65 ft^3/day/ft = 0.0039 ft^3/min/ft = 0.000065 ft^3/sec/ft
Q = 0.029 gpm/ft

b. Max pipe capacity: Assume 4-inch, 6-inch, and 8-inch diameter corrugated polyethylene pipe on a 1% slope after projected potential differential settlement.

Manning's n = 0.016 ("ADS Specifier Manual - Civil Engineer", Advanced Drainage Systems, Inc.)

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Pipe Diameter	Pipe Area	Hydraulic Radius	Flow Capacity		Pipe Length
(In)	(ft^2)	(ft)	(cfs)	(gpm)	(ft)
3	0.20	0.79	1.25	9	321
4	0.35	1.05	2.68	20	692
6	0.79	1.57	7.91	59	2,039
8	1.40	2.09	17.03	127	4,392
10	2.18	2.62	30.87	231	7,963

6-inch diameter pipe may be used for the upper 2,000 feet of each phase area and 8-inch diameter pipe for the rest of the system to the sumps. Since the cost difference is low, use 8-inch diameter pipe for the entire length of the leachate conveyance piping.

GEOTEXTILE FILTER FA

I. Geotextile filter fabric is to be placed on top of the drainage net to serve as a filter for the overlying materials. Check design criteria of Table 3-3 p3-30 "Geotextile Engineering Manual" by U.S. Department of Transportation" to determine the soil retention and permeability criteria that must be met.

A. Native Soil Properties will be used to design the filter fabric. Other materials may be used a cover soil, however due to the high fines content of the native materials they will lead to a more conservative design. Permeability is the exception in that a higher permeability of the cover soil is more conservative. Therefore the conductivity will based on the highest cover soil conductivity that might be encountered.

B. Soil Retention

A sieve analysis of the native soil was performed by Kleinfelder[1] on the native soil. The results of this analysis are presented below in Table 1 and Figure 1. From Figure 1 the following soil parameters were estimated.

$D_{10} = 0.01$
$D_{60} = 0.12$

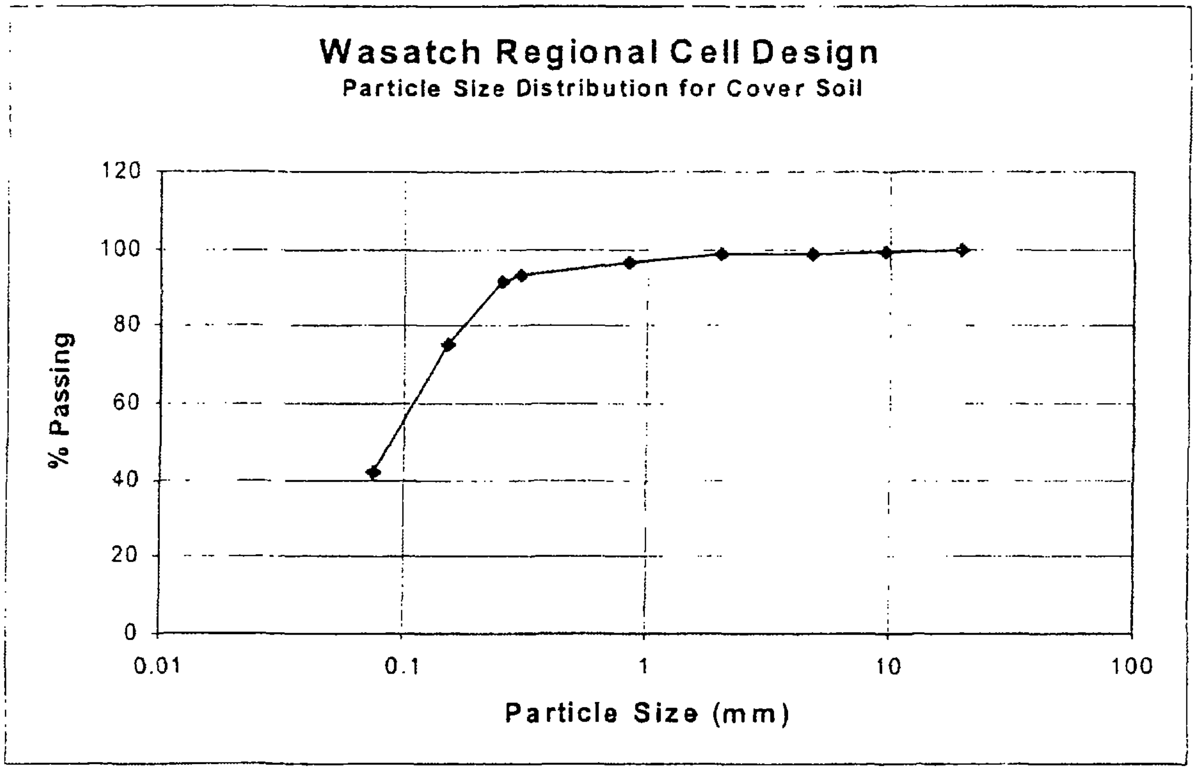
$C_u = D_{60} / D_{10}$
$C_u = 12$

$D_{85} = 0.2$ mm

Table 1

Sieve #	Size (mm)	% Finer
3/4"	20	100
3/8"	9.525	99.5
4	4.75	99
10	2	98.5
20	0.85	96.5
40	0.3	93.5
60	0.25	91.5
100	0.15	75.5
200	0.075	42

[1] Kleinfelder Lab results



Criteria from Table 3-3 of design manual for:

$\leq$ 50% passing the #200 sieve.

AOS (O_{95}) = EOS $\leq B^*D_{85\,(soil)}$

where: $B = 1$ for $C_u \leq 2$ or $C_u \geq 8$

$B = 0.5C_u$ for $2 \leq C_u \leq 4$

$B = 8/C_u$ for $4 < C_u < 8$

and:

$$C_u = D_{60\,(soil)}/D_{10\,(soil)}$$

Since C_u is greater than 8 for the native soil.

$B = 1$

EOS $\leq D_{85}$

EOS $\leq$ 0.2 mm (approx. sieve #80)

C. Permeability Criteria

$$k_{v\,(fabric)} \geq 10^* k_{v\,(soil)}$$
$$k_{v\,(fabric)} \geq 10^* (10^{-3} \text{cm/sec})$$
$$k_{v\,(fabric)} \geq 10^{-2} \text{ cm/sec}$$

III. Check the strength of the Filter Fabric against Burst Resistance. Since the geotextile fabric is being placed on the geonet, the fabric must have sufficient strength to bridge the ridges of the geonet without failure. According to Robert M. Koerner (1990) in "Designing with Geosynthetics" (published by Prentice-Hall, Inc.) the required fabric burst strength to bridge the gap is:

$$T_{req'd} = p'd_v$$

where

$T_{req'd}$	=	the required fabric strength
p'	=	the stress at the fabric's surface, which in the worst case would equal the overburden stress at closure
d_v	=	the maximum void diameter, or in this case the gap distance between ridges of the geonet = 0.4 inches

The Normal Bearing Pressure (P'):

250' Waste at 80 pcf	= 20,000 psf
2 + 2' Soil Protective Cover at 120 pcf	= 480 psf
	20,480 psf
N TOTAL	= 142.22 psi

Thus, $T_{req'd} = (142.22)(0.4) = 56.9$ psi

The geotextile will be designed using the design-by-function concept recommended by EPA for the design of hazardous waste facilities. According to EPA seminar publication Requirements for Hazardous Waste Landfill Design, Construction, and Closure (1989, pg. 56), "whatever parameter of a specific material one is evaluating, a required value for the material must be found using a design model and an allowable value for the material must be determined by a test method. The allowable value divided by the required value yields the design ratio, or the resulting factor of safety." Thus in evaluating the tensile strength requirement for the filter fabric, an allowable tensile strength is divided by the required tensile strength to determine the factor of safety for the design, or:

Factor of Safety (FS) = $T_{allow}/T_{req'd}$

where

T_{allow} = the allowable tensile strength as obtained from laboratory testing, and

$T_{req'd}$ = the required tensile strength as obtained from design of the actual system

Koerner (1990) in "Designing with Geosynthetics" suggests that additional factors of safety be applies to the tensile strength value found by test method to account for installation damage, creep and for biological and chemical degradation. In accordance with the procedures recommended by Koerner (1190), an additional factor of safety of 1.2 will be applied to the tensile strength found by test method for installation damage, an additional factor of safety of 1.2 will be applied to the tensile strength value for creep, and an additional factor of safety of 1.5 will be applied to test tensile strength for potential biological and chemical degradation. This value becomes the allowable value to be used in the equation above. This is in addition to the factor of safety to be used in the design-by-function concept discussed above. Thus,

$$T_{allow} = \frac{T_{given}}{(1.2x1.2x1.5)} = \frac{t_{given}}{2.16}\frac{lbs}{ft^2}$$

Assuming a design-by-function FS of 2 then

$2 = T_{allow}/T_{req'd}$
$T_{given}/2.16 = 2 * T_{req'd}$
$T_{given} = 2 * 2.16 * T_{req'd}$
$T_{given} = 2 * 2.16 * 56.9$ psi
$T_{given} = 245.8$ psi

This T_{given} was determined based on the full 250 feet of waste. Since that will not be the case over the entire landfill, the following T_{given} of 200 psi will result in a waste height of:

200 psi = T_{given}
$T_{req'd} = T_{given}/ (2 * 2.16)$
$T_{req'd} = 200 / (2 * 2.16)$
$T_{req'd} = 46.29$ psi

And since $T_{req'd} = p'd_v$ where $d_v = 0.4$ inches

$p' = T_{req'd}/d_v$
$p' = 46.29/0.4$
$p' = 115.7$ psi = 16,666.7 psf

Subtracting out the Soil Protective Cover

Waste Bearing Pressure = 16,666.7 -480 = 16,186.7 psf

The waste height, assuming 80 psf for the waste is

Waste Height = 16,186.7/80 = 202.3 ft

Therefore, where the waste height does not exceed 200 feet, a geosynthetic meeting 200 psi for T_{given} may be used.

IV. Koerner (1990) also defines another process acting on the fabric at the same time as the tendency to burst. This is one of tensile stress being mobilized by in-place deformation. This would occur when the geotextile fabric is locked into position by the soil above it and the ridges of the geonet below it. A lateral or in-place stress could be mobilized if two ridges of the geonet were to give or spread outward from the load of the soil placed on top. The maximum strain would occur if the ridges folded over completely, thus stressing the filter fabric. This maximum strain would be equal to the height of the ridges divided by the original gap separation. The height of each ridge is approximately 0.3 inches. The gap separation between the ridges in 0.4 inches. Thus, the maximum strain would be 0.3/0.4 = 0.75 or 75%. Koerner defines the tensile force being mobilized as being related to the pressure exerted on the fabric as follows:

$$T_{req'd} = p'(e)^2$$

$T_{req'd}$	=	the mobilized tensile force
p'	=	the applied pressure which would equal the overburden stress at closure = 142.2 psi.
e	=	the strain of the geotextile between contact points,
	=	0.75

Thus, $T_{req'd} = 142.2(0.75)^2 = 80.0$ psf for the 250 ft waste
and $T_{req'd} = 115.7(0.75)^2 = 65.1$ psf

To determine the factor of safety (FS), $T_{req'd}$ is compared with an allowable T which is the grab strength divided by the additional factors of safety referred to above.

$$T_{allow} = \frac{T_{given}}{(1.2x1.2x1.5)} = \frac{T_{given}}{2.16}\frac{lbs}{ft^2}$$

Assuming a FS of 2, then:

For the 250 ft requirement:

$2 = T_{allow}/T_{req'd}$
$T_{given}/2.16 = 2 * T_{req'd}$
$T_{given} = 2 * 2.16 * T_{req'd}$
$T_{given} = 2 * 2.16 * 80.0$ psf
$T_{given} = 345.6$ psf

For the 200 ft requirement:

$2 = T_{allow}/T_{req'd}$
$T_{given}/2.16 = 2 * T_{req'd}$
$T_{given} = 2 * 2.16 * T_{req'd}$
$T_{given} = 2 * 2.16 * 65.1$ psf
$T_{given} = 281.2$ psf

SUMP CAPACITY

I. Determine the sump capacity.

Surface $Area_{top}$ = 3,200 ft^2

Surface $Area_{bottom}$ = 2,756 ft^2

Surface $Area_{average}$ = (3200 + 2756) /2 = 2,978.2 ft^2

Average Depth = (2.5 + 0.6) /2 = 1.6 ft

Total Volume = 2978.2 * 1.6 = 4,765.1 ft^3

Total 8" pipe length = 105.4 ft
Total 24" pipe length = 7.8 ft
8" Pipe Cross Sectional Area = pi*$(4/12)^2$ = 0.349 ft^2
24" Pipe Cross Sectional Area = pi*$(12/12)^2$= 3.14 ft^2

Total Pipe Volume = 105.4*0.349 + 7.8*3.14= 61.3 ft^3

The rock porosity will be assumed to be 0.32

Rock Volume = 4765.1 - 61.3 = 4,703.8 ft^3

Net Volume = 4,703.8*(0.32) + 61.3 = 1,566.5 ft^3

GCL HYDRAULIC COMPA

I. Determine GCL Compatibility with by looking at both hydraulic issues and the HELP model.

A. Hydraulic Issues

One of the critical issues associated with use of a GCL is its ability to minimize the potential of contamination to ground water from migration of leachate water through the lining system as compared to a compacted clay liner. According to a technical paper titled *Technical Equivalency Assessment of GCL's To CCL's* prepared by R.M. Koerner from the Geosynthetic Research Institute, Drexel University and D.E. Daniel from University of Texas at Austin, a hydraulic comparison can best be demonstrated by an application of Darcy's law.

$V = k((H+T)/T)$ where: k = hydraulic conductivity
H = depth of liquid ponded on the liner
T = thickness of the liner

In order to establish equivalency between the GCL and a CCL:

$$V_{GCL} = V_{CCL} \quad \text{or}$$

$$k_{GCL}((H+T_{GCL})/T_{GCL}) = k_{CCL}((H+T_{CCL})/T_{CCL})$$

Substituting in the values of T for the GCL and the values of k and T for the CCL (H is assumed constant), the equation can be solved for and equivalent k required for the GCL. Assuming k_{CCL} = 1 x 10-7 cm/sec, T_{CCL} = 2 feet or about 600 mm and T_{GCL} = 7 mm after hydration, k_{GCL} = 3.4 x 10-9 cm/sec. This is consistent with the hydraulic conductivity of the GCL materials.

$$(3.4E-9cm/\sec)\cdot(\frac{H+0.7cm}{0.7cm}) = (1E-7cm/\sec)\cdot(\frac{H+60cm}{60cm})$$

$$H = 30.3cm = 1ft$$

As can be seen from the comparative analysis presented above, a single GCL is hydraulically equivalent under steady state flow conditions to the two feet of compacted clay liner when the ponding depth is around 1 ft. Completely replacing two feet of compacted clay with a GCL will provide hydraulic equivalence in providing for ground water contamination protection.

B. HELP Model

EPA's Hydrologic Evaluation of Landfill Performance (HELP) model was used previously to model percolation of precipitation water through the lining systems of the current design concept in the floor area. Additional modeling was performed to model percolation of precipitation water through the proposed design concept in the floor area. The results of the

HELP models were compared to provide justification for the proposed lining system. The proposed system should provide an equivalent or better lining system for protection of ground water.

Precipitation, daily temperature, evapotranspiration, and solar radiation data used for modeling of the current system were used for the proposed lining system. The only change to the model was to the bottom layer. The GCL in the current design was changed to a two foot thick CCL with a saturated hydraulic conductivity of 1.0E-7 cm/sec.

Results from the model estimate an average annual leakage rate through the bottom lining system of about 0.169 cubic foot per year for the current design using a GCL and 0.375 cubic foot per year under the design using a CCL. Based on the results from the HELP model, the modified concept provides a reduced estimate of leakage through the bottom lining system.

Client: Allied Waste
Project: Wasatch Regional
Feature: GCL Equivalency
Project No.: 113.30.100

Determine: *The hydraulic equivalency of Geosynthetic Clay Liners (GCL) to Compacted Clay Liners (CCL)*

Darcy's Law provides: $V = k((H+T)/T)$

where: $V =$
$k =$ hydraulic conductivity of liner material
$H =$ depth of liquid ponded on liner material
$T =$ thickness of liner material

Determine V_{CCL}

$H_{CCL} =$ 1.0 ft = 30.48 cm, maximum allowable hydraulic head on the liner outside the sump area
$k_{CCL} =$ 1.0E-07 cm/sec
$T_{CCL} =$ 2.0 ft = 60.96 cm, minimum required thickness at a permeability of 1×10^{-7} cm/sec

Therefore, $V_{CCL} =$ 1.5E-07 cm/sec

Determine V_{GCL}

Tabulate a relationship between k_{GCL} and T_{GCL} as variables to provide equivalency between V_{CCL} and V_{GCL}. T_{GCL} is a hydrated thickness for the GCL material.

$H_{GCL} =$ 1 ft = 30.48 cm, maximum allowable hydraulic head on the liner outside the sump area

k_{GCL}	T_{GCL}		
(cm/sec)	(mm)	(cm)	(in)
1.9E-09	4.0	0.40	0.157
2.4E-09	5.0	0.50	0.197
2.9E-09	6.0	0.60	0.236
3.4E-09	7.0	0.70	0.276
3.8E-09	8.0	0.80	0.315
4.3E-09	9.0	0.90	0.354
4.8E-09	10.0	1.00	0.394
5.2E-09	11.0	1.10	0.433
5.7E-09	12.0	1.20	0.472
6.1E-09	13.0	1.30	0.512
6.6E-09	14.0	1.40	0.551

INDEX FLUX AND PERMEABILITY OF GCL's
TEST RESULTS
ASTM D-5887 / D-5084 / EPA 9100

Client	: CETCO	Date	: 03-13-04
Project Location	: Toole Landfill, Utah	Job No.	: 04LG352.01
Sample Number	: Roll : 516 Lot 200405FA	Tested By	: HT
Description	: Bentomat SDN	Checked By	: JB

Permeant Fluid : Leachate Provided by Client

Physical Property Data

		Initial				Final
Initial Clay Height (in)	:	0.20		Final Height of Clay (in)	:	0.25
Initial Diameter (in)	:	4.00		Final Diameter of Clay (in)	:	4.00
Initial Wet Weight (g)	:	47.20		Final Wet Weight(Clay) (g)	:	69.20
Wet Density (pcf)	:	71.48		Wet Density (pcf)	:	83.84
Moisture Content %	:	22.00	Est	Moisture Content %	:	112.90
Dry Density (pcf)	:	58.59		Dry Density (pcf)	:	39.38

Test Parameters

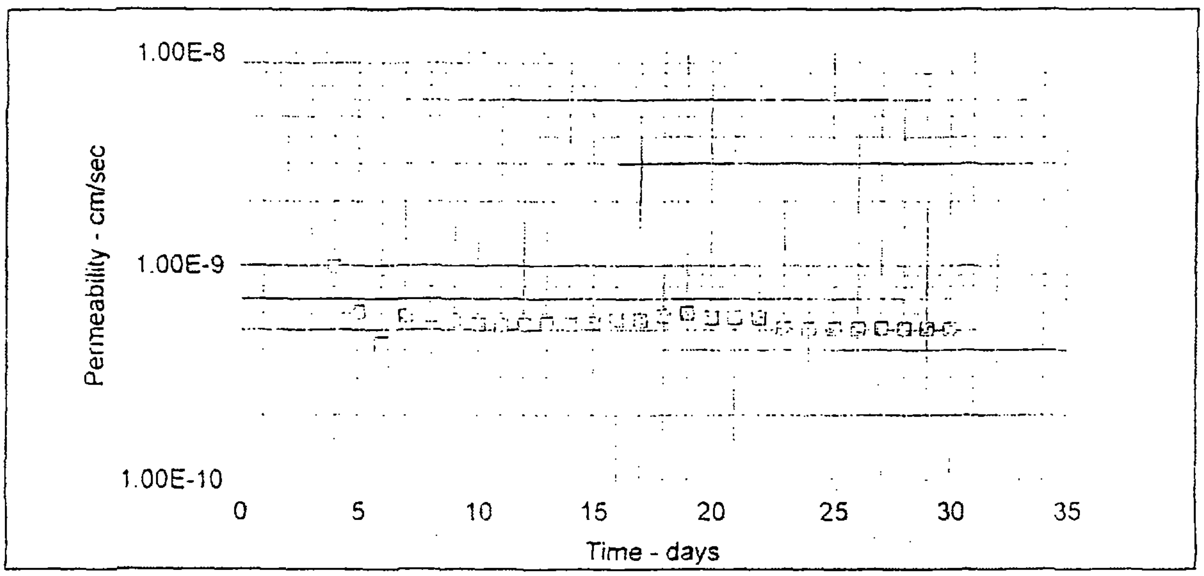
Fluid	:	Site Leachate	**Effective**		
Cell Pressure psi)	:	80.00	**Confining Pressure (psi)**	:	4
Head Water (psi)	:	77.00	Gradient	:	220.80
Tail Water (psi)	:	75.00	Head Differential (psi)	:	2

Flux and Permeability Input Data

Minimum Saturation Time is 48 hours

Area, A = 0.00811 m^2
Thickness, t = 0.25 in

Total Inflow to date : 16.9 cc



JLT Laboratories, Inc. 938 S Central Ave. Canonsburg, Pa 15317 Tel 724-746-4441 Fax 724-745-4261

Daily Readings and Computations

Client : CETCO
Project Location : Toole Landfill, Utah
Sample Number : Roll : 516 Lot 200405FA
Description : Bentomat SDN

Date : 03-13-04
Job No. : 04LG352.01
Tested By : HT
Checked By : JB

Days	Date	Flow cc	Time min	Elapsed Time (sec)	Flux (m^3/m^2)/sec	k cm/sec	Cum Inflow cc
1	02/13/2004	48 hours of hydration per ASTM					
2	02/14/2004						
3	02/15/2004	0.00	0	0			0.0
4	02/16/2004	3.90	1442	86520	5.56E-009	9.89E-010	3.9
5	02/17/2004	2.40	1441	86460	3.42E-009	6.09E-010	6.3
6	02/18/2004	1.70	1445	86700	2.42E-009	4.30E-010	8.0
7	02/19/2004	2.30	1444	86640	3.27E-009	5.82E-010	10.3
8	02/20/2004	2.30	1442	86520	3.28E-009	5.83E-010	12.5
9	02/21/2004	2.20	1443	86580	3.13E-009	5.57E-010	14.8
10	02/22/2004	2.10	1440	86400	3.00E-009	5.33E-010	16.9
11	02/23/2004	2.00	1388	83280	2.96E-009	5.27E-010	18.9
12	02/24/2004	1.90	1310	78600	2.98E-009	5.30E-010	20.8
13	02/25/2004	2.10	1439	86340	3.00E-009	5.33E-010	22.9
14	02/26/2004	2.10	1445	86700	2.99E-009	5.31E-010	25.0
15	02/27/2004	2.20	1501	90060	3.01E-009	5.36E-010	27.2
16	02/28/2004	2.20	1442	86520	3.14E-009	5.58E-010	29.4
17	02/29/2004	2.20	1445	86700	3.13E-009	5.56E-010	31.6
18	03/01/2004	2.30	1442	86520	3.28E-009	5.83E-010	33.9
19	03/02/2004	2.25	1368	82080	3.38E-009	6.01E-010	36.2
20	03/03/2004	2.25	1441	86460	3.21E-009	5.71E-010	38.4
21	03/04/2004	2.30	1475	88500	3.21E-009	5.70E-010	40.7
22	03/05/2004	2.25	1442	86520	3.21E-009	5.70E-010	43.0
23	03/06/2004	2.00	1440	86400	2.86E-009	5.08E-010	45.0
24	03/07/2004	2.00	1441	86460	2.85E-009	5.07E-010	47.0
25	03/08/2004	2.00	1439	86340	2.86E-009	5.08E-010	49.0
26	03/09/2004	2.00	1443	86580	2.85E-009	5.07E-010	51.0
27	03/10/2004	2.00	1437	86220	2.86E-009	5.09E-010	53.0
28	03/11/2004	2.00	1444	86640	2.85E-009	5.06E-010	55.0
29	03/12/2004	2.00	1442	86520	2.85E-009	5.07E-010	57.0
30	03/13/2004	2.00	1447	86820	2.84E-009	5.05E-010	59.0

WASTE RUNOFF CONTA

Purpose: To determine the capacity requirements for runoff containment within the active landfill.

Method: The SCS curve number method as described in Technical Release No. 55.

Required: In order to calculate the runoff volume, the following steps and information are required:

- Tributary area contributing to runoff.
- A Representative Soil Conservation Service(SCS) curve number (CN).
- 25-year 24-hour precipitation depth as required by regulation.

Delineation: Runoff will be determined based on the volume generated per acre of open and active cell area.

Curve Numbers: The curve number was determined based assumptions made for the daily cover to be used during landfill operation. The soil used for daily cover will consist of on-site soils and are of the type B hydrologic soil group based on information and soils defined in the NRCS study "Soil Survey of Tooele Area, Utah." Table 2-2d of Technical Release 55 provides a curve number of 82 for dirt road type conditions (including the right-of-way) with type B soils. Daily cover soils are placed and compacted using a dozer or landfill compactor type equipment that leaves an irregular surface that will provide additional interception storage beyond that of a dirt road and probably beyond that of a dirt road plus the right-of-way because of the individual ponding areas provided by the equipment. Using a curve number of 82 should provide representative, but conservative, results for the daily cover material.

Precipitation: Design for the 25-year 24-hour precipitation event is required by regulations for MSWLF's. The rainfall amounts were taken from the "Point Precipitation Frequency Estimates from NOAA Atlas 14". The precipitation depth value used is 2.06 inches.

Calculations:

Rainfall runoff depth (Q) is determined by:

$Q = ((P-0.2S)^2)/(P+0.8S)$ Where: Q = Runoff depth (inches)

P = Precipitation depth (inches)

S = Potential maximum retention after runoff begins (inches) = (Ia)/(0.2)

Where Ia = Initial abstraction (inches)

Also S is related the SCS curve number (CN) as follows:

$S = (1000/CN)-10$

Determine Runoff Depth Per Acre of Area

$S = (1000/82)-10 = 2.20$

$Q = ((2.06-0.2(2.2))^2)/(2.06+0.8(2.2)) = 0.69$ inches

Runoff quantity per acre is 0.69/12 = 0.06 acre foot per acre = 2,613 cf/acre

Conclusion:

Required runoff containment capacity is, therefore, 0.06 acre foot (2,613 cf) per acre of open cell area. Therefore, for the first phase of construction the containment capacity for approximately 20 to 22 acres is 1.2 to 1.32 acre-feet (52,272 to 57,500 cf). This containment capacity may be provided in a number of ways including:

- A waste set-back from the inside slope of the cell.
- A ponding area on the waste surface.
- Ditches between the waste and the interior slope of the cells.
- Providing separate lined runoff containment storage areas.
- A combination of the above or any other method that will provide the required containment capacity.

Runoff water may be used inside the lined cell areas for dust control and compaction.

We recommend that facility operators provide a minimum of two feet freeboard within all containment areas provided.

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.85579°N 112.75219°W 4435 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Thu Nov 18 2004

Confidence Limits | Seasonality | Location Maps | Other Info. | Grids | Maps | Help | Docs | U.S. M

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.14	0.22	0.27	0.37	0.45	0.56	0.63	0.80	0.99	1.27	1.45	1.64.	1.85	2.06	2.58	3.05	3.67	4.30
5	0.20	0.30	0.38	0.51	0.63	0.74	0.81	0.98	1.21	1.54	1.77	2.02	2.28	2.51	3.12	3.70	4.41	5.16
10	0.25	0.38	0.47	0.64	0.79	0.90	0.96	1.14	1.38	1.76	2.04	2.33	2.62	2.87	3.54	4.21	4.97	5.81
25	0.33	0.51	0.63	0.84	1.04	1.16	1.21	1.38	1.64	2.06	2.40	2.77	3.09	3.36	4.08	4.87	5.69	6.64
50	0.40	0.62	0.76	1.03	1.27	1.40	1.43	1.57	1.84	2.29	2.69	3.12	3.45	3.73	4.47	5.37	6.21	7.23
100	0.49	0.75	0.93	1.25	1.54	1.67	1.70	1.80	2.06	2.52	2.98	3.48	3.83	4.11	4.87	5.86	6.72	7.81
200	0.59	0.90	1.11	1.50	1.86	1.99	2.02	2.09	2.31	2.75	3.29	3.86	4.21	4.49	5.24	6.34	7.19	8.34
500	0.75	1.14	1.41	1.90	2.35	2.50	2.52	2.59	2.75	3.08	3.70	4.38	4.73	4.98	5.72	6.96	7.79	9.01
1000	0.89	1.35	1.68	2.26	2.80	2.95	2.97	3.03	3.13	3.36	4.01	4.79	5.13	5.36	6.06	7.41	8.21	9.47

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

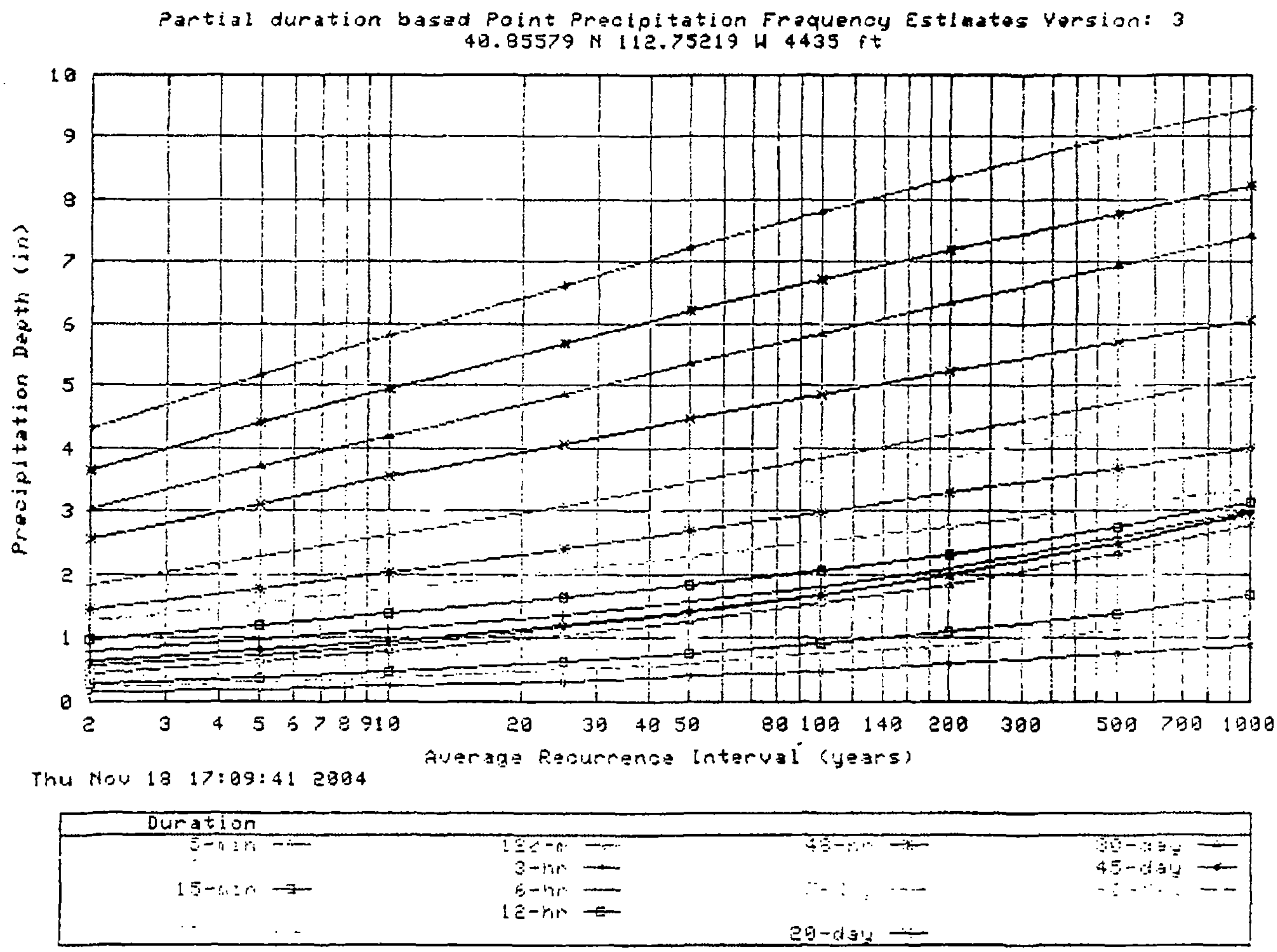


Table 2-2a Runoff curve numbers for urban areas [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

APPENDIX 7
FACILITY MODIFICATIONS (VECTOR)

APPENDIX 7.1
Permit Modification Request

PERMIT MODIFICATION REQUEST
for the
WASATCH REGIONAL LANDFILL
Tooele, Utah

Prepared for:

Allied Waste, Inc.
1111 West Highway 123
East Carbon, UT 84520
(435) 888-4418

Prepared by:

VECTOR ENGINEERING, INC.
An Ausenco group company

143E Spring Hill Drive
Grass Valley, CA 95945
(530) 272-2448

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3/31/11
State of Utah

Project No. 061204.11
February 2009

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

Allied Waste Industries, Inc. (Allied) is seeking to modify the configuration and operation of the Wasatch Regional Class V Landfill (WRL) by:

1. Increasing the maximum landfill elevation by approximately 100 feet.
2. Adding a Class VI, Construction and Demolition (C&D) cell within the existing landfill property.

This document describes the applicable features of the existing facility and the proposed modifications, and provides the engineering analyses performed in support of the modifications in compliance with the State of Utah Solid Waste Permitting and Management Rules R315-301 through 320.

2.0 LANDFILL DESCRIPTION

2.1 Location

The WRL is located west of the Great Salt Lake and adjacent to the east side of the Lakeside Mountain Range in Tooele County, Utah. The WRL is located west of Rowley Road in Tooele County, Utah, within Section 32, 33, and 34 of Township 2 North, Range 8 West, and within Sections 3 and 4 of Township 1 North, Range 8 West, Salt Lake Base and Meridian.

2.2 Climate

The site climate is arid with an average annual rainfall of 12.9 inches. Maximum precipitation months are March, April and May, whereas June, July and August are the drier months of the year. In addition, the site receives an average annual snowfall depth of 33.5 inches (Western Regional Climate Center).

2.3 Owner and Operator

The WRL is co-owned by Allied and the State of Utah School and Institutional Trust Lands Administration. It is operated by Allied.

2.4 Subsurface Conditions

The subsurface characteristics are described in Attachment 1 as part of the slope stability report.

2.5 Current Permit

The WRL currently operates under a permit issued by the Utah Division of Solid and Hazardous Waste. That permit was issued in association with the permit document titled "Municipal Solid Waste Landfill Permit Modification Design Engineering Report" (Hansen, Allen and Luce), dated December 2004 and revised in June 2005. The current permit does not include a provision for a Class VI cell at the landfill. It is the intent of this permit modification that the existing permit document remains in full effect relative to all WRL features and elements not addressed as part of this modification.

2.6 Current Landfill Configuration

The current configuration of the WRL is shown on Figure 1. The current ultimate configuration (master plan) for the WRL is shown on Figure 2. The final waste slopes are designed at 4H:1V with 25 foot-wide benches located every 50 feet vertically. The WRL was initially permitted for eleven phases covering approximately 793 acres with an ultimate gross airspace of approximately 160 million cubic yards.

The existing liner system consists of (from the bottom up):

- Prepared subgrade;
- Geosynthetic clay liner (GCL) (non-reinforced on the floor and reinforced on the sideslopes);
- 60-mil HDPE geomembrane (smooth on the bottom and textured on the sideslopes);
- Leachate collection and recovery system (LCRS) consisting of geonet overlain with non-woven geotextile filter fabric (on floor only); and
- Protective soil cover layer.

Existing stormwater control consists of a series of channels, benches, and downdrains which control run-on, from areas outside the landfill footprint and run-off, from areas within the landfill footprint. All stormwater from the site is diverted into the existing groundwater cutoff trench located to the east of the landfill. Stormwater controls are designed and constructed as the landfill expansion progresses.

3.0 FACILITY MODIFICATIONS

Two modifications are proposed for the WRL:

1. Increasing the maximum landfill elevation by approximately 100 feet, and
2. Adding a Class VI cell within the existing landfill property for construction and demolition (C&D) disposal.

This section describes the proposed modifications and presents the results of engineering analyses performed to support the modifications.

3.1 Vertical Expansion

The currently permitted maximum elevation of the WRL will be increased approximately 100 feet across the landfill footprint. This height increase will raise the maximum landfill elevation to approximately 4,620 feet. No associated horizontal expansion is proposed.

3.1.1 Configuration

The modified final cover grading plan is shown on Figure 3. The waste fill geometries (slopes, grades, benches) will remain the same as the current landfill. A typical section is shown on Figure 4. This modification will increase the gross landfill airspace from 160 million cubic yards to 220 million cubic yards.

The stability of the proposed configuration was analyzed using site specific soils and geosynthetic data obtained as part of project-specific laboratory testing programs performed for the last three expansions at the site. The methodology and results are presented in Attachment 1 titled *Waste Fill Stability Evaluation of the Wasatch Regional Landfill, Utah* (Vector 2008). The results of the stability analyses indicate that for static conditions the proposed landfill design is stable using the current liner system (FS = 1.7). The factor of safety for the pseudo-static condition was below 1.0 so a displacement analysis was performed. This analysis indicates displacements less than 1 inch for both liner options, which is also within acceptable industry standards for displacement during a seismic event. The static and seismic stability analysis and displacement analysis are discussed in detail in Attachment 1.

An infinite slope analysis was performed to check the stability of the final cover. Results and methods of this analysis are presented in detail in Attachment 1. The results of the analysis indicate the static factor of safety between 2.8 and 3.0 and pseudo-static factors of safety between 1.7 and 1.8.

3.1.2 Liner

The slope stability analyses performed were based on the current liner configuration. Based on the results of the stability analyses, the proposed landfill height increase will result in no changes to the liner system for the landfill.

3.1.3 Leachate Collection and Removal System

The proposed modification will require no changes to the leachate collection and removal system (LCRS) for the landfill.

The HELP model was run for the existing permit (Hansen, Allen, and Luce, 2004). The model was run for waste heights of 0, 10, 50, 100, and 200 feet. The results of the HELP modeling indicate that a waste height of 100 feet produces the highest peak daily discharge rate of 0.242 inches, and the annual leachate is the same for all heights. Based on this analysis and our experience with the HELP model, a vertical expansion of the landfill will reduce the peak daily leachate generation, therefore a recalculation of the leachate generation is not necessary for this permit modification. Performance of the geocomposite and leachate collection pipes under the additional loading was analyzed as described in the following sections.

3.1.3.1 Geonet / Geocomposite

The peak daily discharge rate of 0.242 inches from the HELP model was used for sizing the geonet in the existing permit for a 100' high waste height (Hanson, Allen, and Luce, 2004). At this rate the required transmissivity of the geocomposite was determined to be 1.023 x 10^{-3} m^2/sec. The requirement for a material that meets this transmissivity does not change for the additional waste thickness. However overburden loading, which has an effect on the transmissivity, will increase. In the current design documents, it was estimated that the overburden loading will range from 2,500 lb/ft^2 to 20,000 lb/ft^2 depending on the location within the landfill. Waste thickness generally increases in the landfill to the north and west with the maximum fill height occurring in the northwestern limits of the landfill. The additional waste will increase the maximum waste thickness to approximately 300 feet in this section, corresponding to a 22,500 lb/ft^2 overburden (assuming 75 lb/ft^3 as the unit weight of the waste as recommended by Kavazanjian (1999)). This increase in overburden pressure on the geocomposite will require the geocomposite be tested under higher loads during future design and construction projects. As in the existing permit, the required loading for geocomposite testing will be increased corresponding to the final waste thickness. According to GSE Lining Technology, Inc. a leading manufacturer of geocomposite material, products are available to provide the required transmissivity at the proposed loading.

The geocomposites previously installed in phases 1A, 1B, 2A, and 2B were evaluated for performance under the increased loading from the vertical expansion. The vertical expansion will increase the maximum depth of waste in parts of the existing landfill by approximately 75 feet for a maximum waste depth of 215 feet. Due to the gentle 4H:1V outer waste slopes, the majority of areas in the existing phases will remain unchanged and will have waste depths between 0 and 120 feet. Based on these waste depths, the maximum daily discharge rate from the HELP computer simulation results presented in the WRL Design Engineering Report by

Hansen Allen and Luce (2004) is 0.242 inch, corresponding to 100 feet of waste. The HELP simulation and past experiences indicate that increasing the height of waste will reduce the volume of daily leachate generated.

The McEnroe (McEnroe, 1993) and Giroud (Giroud et. al., 2000) methods for determining required transmissivity were used to re-evaluate the geocomposite transmissivity requirement to transport the daily leachate generated. Assuming a unit weight of 75 lb/ft^3 (Kavazanjian, 1999) for waste material, the maximum depth of approximately 215 feet corresponds to a maximum overburden pressure of 16,125 lb/ft^2 in the existing liner areas. Reduction factors were applied to account for degradation of the geocomposite throughout the life of the landfill (GRI GC8, 2001). Table 1 shows the input parameters used in the McEnroe and Giroud equations.

TABLE 1
TRANSMISSIVITY CALCULATION PARAMETERS

PARAMETER	DEFINITION	VALUE
S	Slope of landfill floor	2.68%
Qh	Inflow (from HELP)	0.242 in/day
L	Length of leachate flow in geocomposite	140 ft
tLCL	Thickness of LCRS layer	2 ft
RFin	Intrusive Reduction Factor	1.2
RFcr	Creep Reduction Factor	3.5
RFcc	Chemical Clogging Reduction Factor	1.5
RFBC	Biological Clogging Reduction Factor	1.3
FSd	Overall factor of safety for drainage	2

The creep reduction factor, RFcr, is influenced by the compressibility of the geocomposite core and is intended to account for the reduction in cross-sectional area that occurs under large, sustained loading. The creep reduction factor can be determined from laboratory strain tests on the geocomposite core. Typical strain tests (such as ASTM D6364) are time consuming tests that can take longer than 10,000 hours to conduct (ASTM D6364, 2004). As an alternative, a conservatively high creep reduction factor of 3.5 was assumed in the analysis. The typical range for creep reduction factors is from 1.4 to 2.0 (Koerner, 1994). Furthermore, the GSE Fabrinet HF, installed in phases 2A and 1B can be expected to creep approximately 50% (RFcr = 1.5) under a 25,000 lb/ft^2 loading based on previously conducted research (Li, 2008). Therefore, the 3.5 creep reduction factor used in the analyses is conservative for the loads resulting from the height increase.

Based on the analysis performed for the existing geocomposites and the proposed overburden, the existing landfill phases will require a geocomposite with a transmissivity of 1.02x10-3 m2/s based on the McEnroe solution or 1.80x10-3 m2/s based on the Giroud solution. The McEnroe and Giroud calculation sheets are shown in Attachment 2. The project specifications for the LCRS geocomposites used in the four existing landfill phases are listed in Table 2. In all previously constructed phases, the project specifications are greater than the minimum required transmissivity determined from the McEnroe and the Giroud solutions.

TABLE 2
SUMMARY OF INSTALLED GEOCOMPOSITES

PHASE	GEONET/GEOCOMPOSITE IN PLACE	PROJECT TRANSMISSIVITY SPECIFICATION (M2/SEC) ASTM D 4716
1A	200 mil HyperNet (XL4000N004)	1x10-3 @ 12,000 psf
1B	GSE Fabrinet HF XL5 (F510800005)	1x10-3 @ 12,000 psf
2A	GSE Fabrinet HF XL5 (F510800005)	1x10-3 @ 12,000 psf
2B	Skaps TN220-1-8	1x10-3 @ 12,000 psf

Third party geosynthetics conformance testing conducted during construction verified that the geocomposites installed in each phase met or exceeded the project specifications.

Based on the results of the above analysis the geocomposites currently installed in the existing phases of the landfill will perform as designed under the increased loading from the vertical expansion.

3.1.3.2 Leachate Collection Pipe

The 8" ADS Type C CPE leachate collection pipes currently used for leachate collection and transport to the sumps were evaluated for excessive deflection from the increased overburden pressure using the Burns-Richard solution. The Burns-Richard solution is an empirical method of estimating pipe deflections based on field and laboratory observations which uses pipe and surrounding soil material properties to determine pipe reaction to overburden.

The Burns-Richard Solution for the ADS 8" corrugated pipe currently installed at WRL estimated pipe deflections from the overburden to be approximately 7%, or 0.6 inch. This calculation shows that under the maximum overburden pressure the pipe used for the LCRS will be structurally sound and the additional pressure will not cause significant deformation. Pipe deflection calculations are included in Attachment 2. The 100 ft. vertical expansion will not warrant additional engineering or design changes for piping used for the LCRS. Additionally pipes currently installed in existing phases of the landfill will perform as designed under the additional loading from the vertical expansion.

3.1.4 Stormwater Control

The proposed modification will result in no changes to the overall drainage area or site hydrology. The existing stormwater control facilities and drainage flow patterns will, at a conceptual level, remain the same. Detailed design for the drainage control facilities will be conducted as build-out of the landfill progresses taking into account the revised final configuration of the landfill.

3.1.5 Monitoring Facilities

The proposed modification will result in no changes to the existing monitoring facilities.

3.2 Class VI Cell

A new, hydraulically-separated cell will be constructed adjacent to the existing landfill for the disposal of construction and demolition material. The cell will be permitted as a Class VI cell in accordance with the State of Utah Solid Waste Permitting and Management Rules R315-301-2(12). The Class VI cell is adjacent to the existing landfill and thus the site characteristics associated with the new cell are consistent with those for the landfill.

3.2.1 Configuration

The Class VI cell bottom grading plan is shown on Figure 5. The sideslopes will be graded at 2H:1V and the bottom will be graded flat. The maximum depth of the excavation will be approximately 34 feet. The final grading plan is shown on Figure 6. The maximum height of the fill will be approximately 100 feet, with 3H:1V slopes and no intermediate benches and a top deck slope of 5%. The cell will have a footprint area of approximately 488,000 square feet (11.2 acres) and an estimated gross capacity of 780,000 cubic yards. A 30 foot wide perimeter road will be designed around the Class VI cell and between the Class VI cell and the existing Class V landfill.

3.2.2 Liner

The Class VI cell will be unlined.

3.2.3 Leachate Collection and Removal System

The Class VI cell will not have a leachate collection and removal system.

3.2.4 Stormwater Control

Drainage and collection structures for surface runoff will be designed to contain a 25-year storm. The design will also include elements to prevent surface water run-on from a 25-year storm.

3.2.5 Final Cover

The Class VI cell will use the evapotranspirative final cover described in the report entitled *Evapotranspirative (ET) Final Cover Permitting Report for the Wasatch Regional Landfill*, Vector Engineering, June 2004.

4.0 REFERENCES

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GRAPHIC SCALE

250' 0' 125' 250' 500' 1000'

LEGEND

- EXISTING 10 FT CONTOUR
- EXISTING 2 FT CONTOUR
- EXISTING 25 FT CONTOUR
- EXISTING 5 FT CONTOUR
- EXTENTS OF PHASE

NOTES:
1. EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY PERFORMED BY OLYMPUS AERIAL SURVEYS, INC. ON MARCH 3, 2008

REV NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 07/30/2008
DESIGNED BY: BGA
DRAWN BY: RPB
CHECKED BY: JVR
APPROVED BY: JVR

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An Ausenco Group Company
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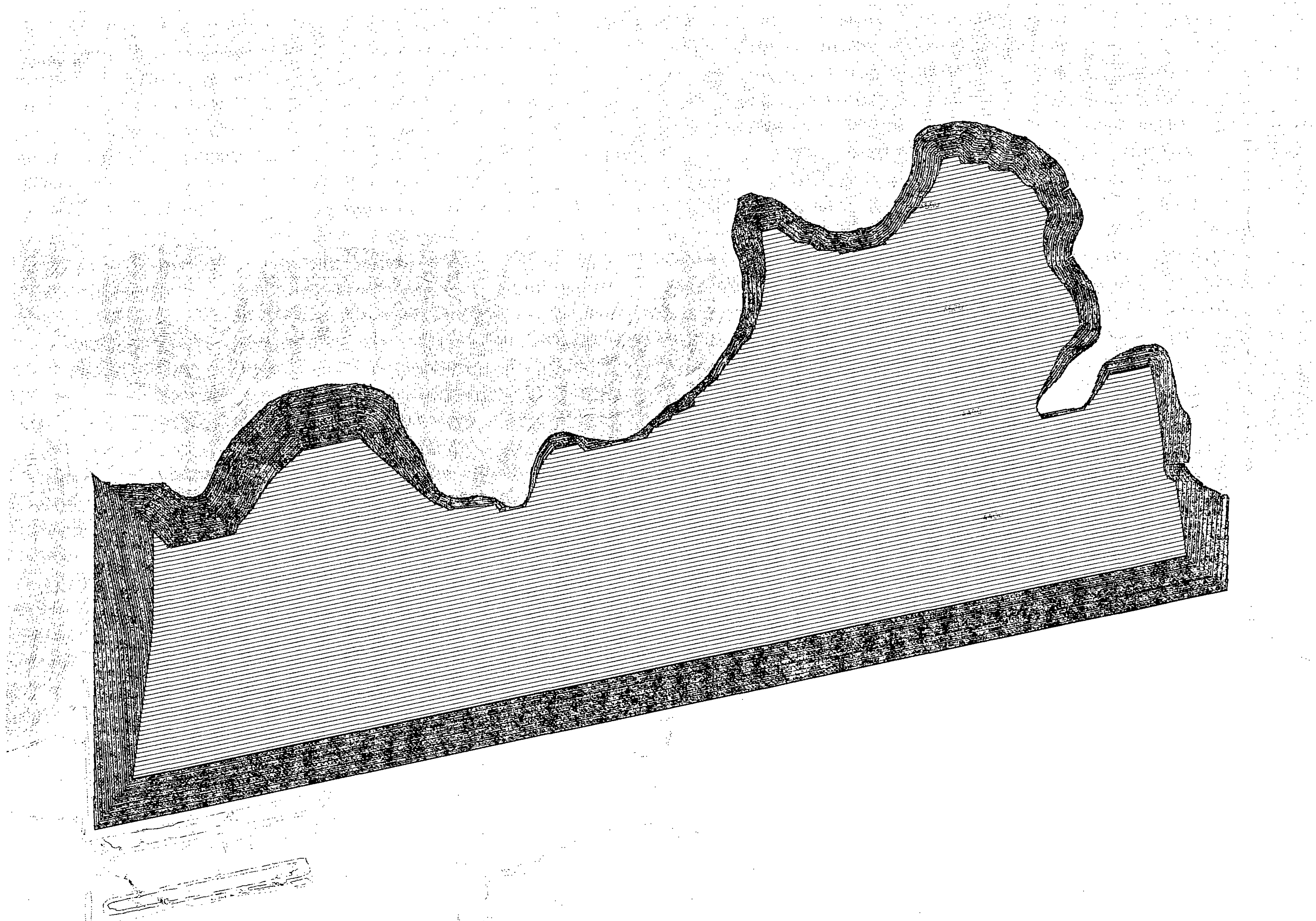
THE AMERICAS • ASIA • AUSTRALIA

WASATCH REGIONAL LANDFILL, INC.

WASATCH REGIONAL LANDFILL
PERMIT REVISION
TOOELE COUNTY, UTAH
EXISTING SITE CONDITIONS

FIGURE NO. 1
PROJECT NO. 061204.11

PERMIT DRAWING



GRAPHIC SCALE

LEGEND

QUANTITIES

REV. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 07/30/2008
DESIGNED BY: BGA
DRAWN BY: EPB
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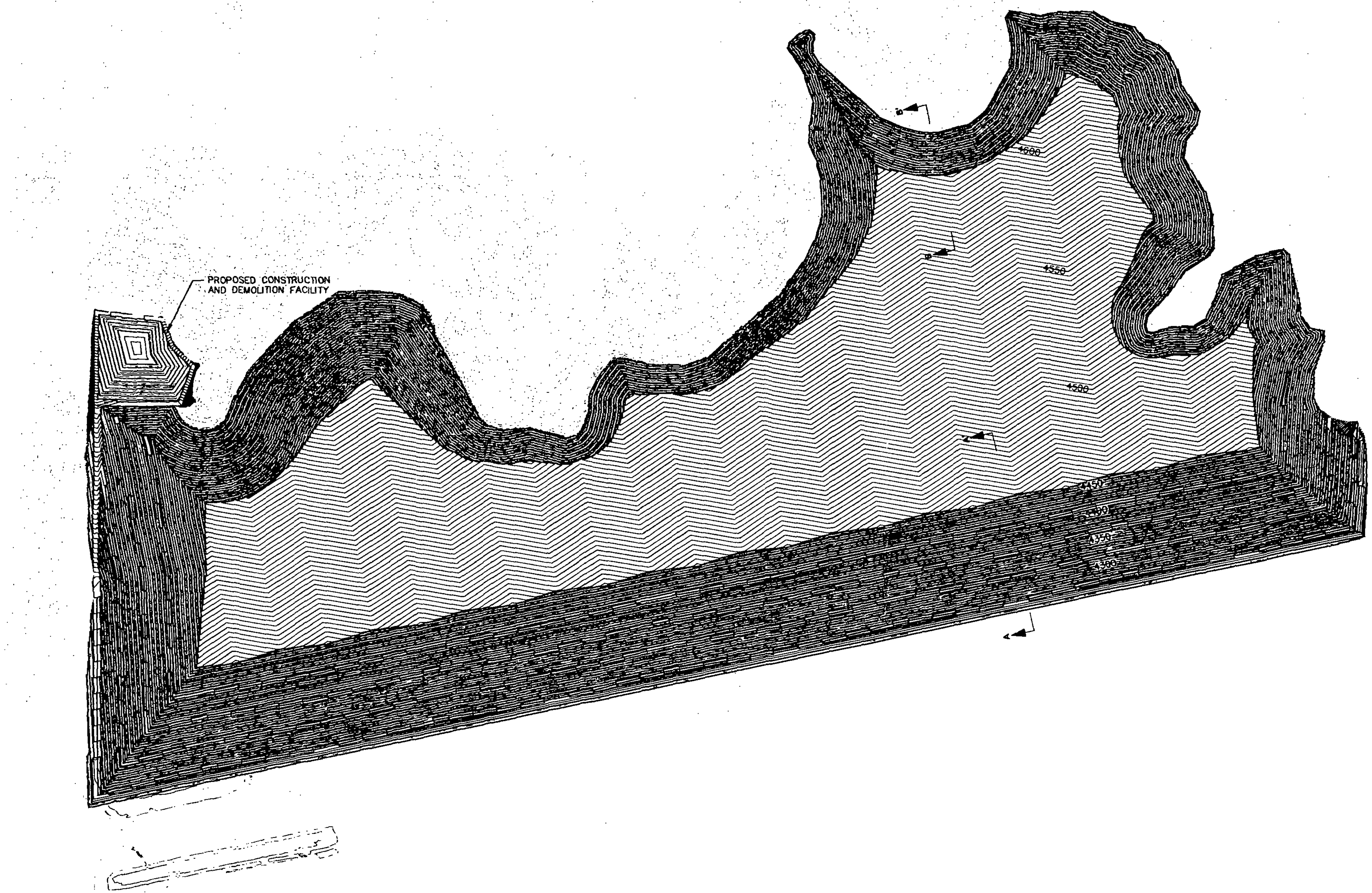
PERMIT REVISION
TOOELE COUNTY, UTAH
EXISTING PERMIT FINAL COVER GRADE

FIGURE NO. 2
PROJECT NO. 061204.11

PERMIT DRAWING



GRAPHIC SCALE

500' 0' 250' 500' 1000' 2000'

LEGEND

	EXISTING 10 FT CONTOUR
	EXISTING 2 FT CONTOUR
	EXISTING 25 FT CONTOUR
	EXISTING 5 FT CONTOUR
2860	PROPOSED FINAL COVER 10 FT CONTOUR (2)
	PROPOSED FINAL COVER 2 FT CONTOUR (2)
- - - - - -	C&D FACILITY LIMITS

QUANTITIES

REVISED FINAL FILL PLAN AIRSPACE = 220,000,000 CY

NOTES:
1. EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY PERFORMED BY OLYMPUS AERIAL SURVEYS, INC. ON MARCH 3, 2008.
2. FUTURE BENCHES NOT SHOWN ON WEST SIDE OF LANDFILL

V. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 07/30/2008
DESIGNED BY: BGA
DRAWN BY: RPB
CHECKED BY: JVR
APPROVED BY: JVR

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WASATCH REGIONAL LANDFILL, INC.

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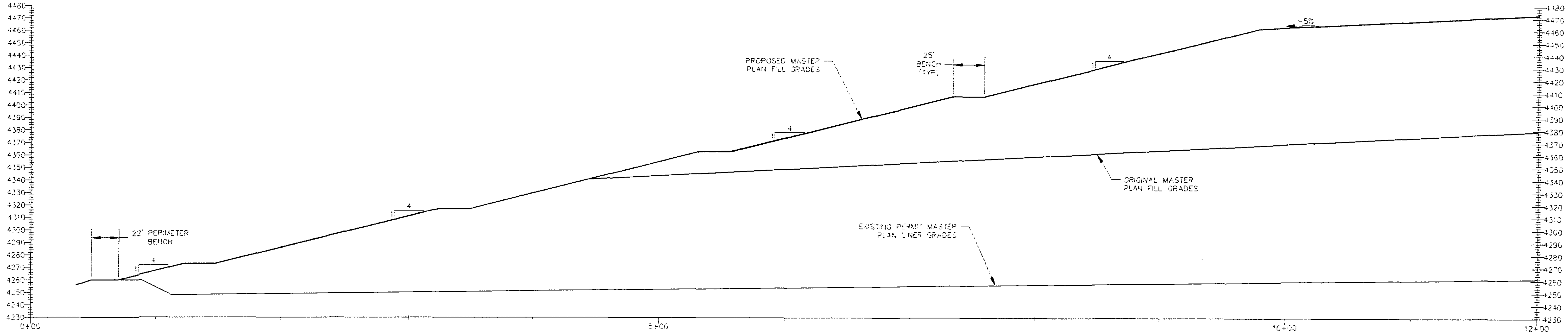
PERMIT REVISION
TOOELE COUNTY, UTAH
LANDFILL REVISED FINAL COVER GRADE

FIGURE NO. 3
PROJECT NO. 081204.11

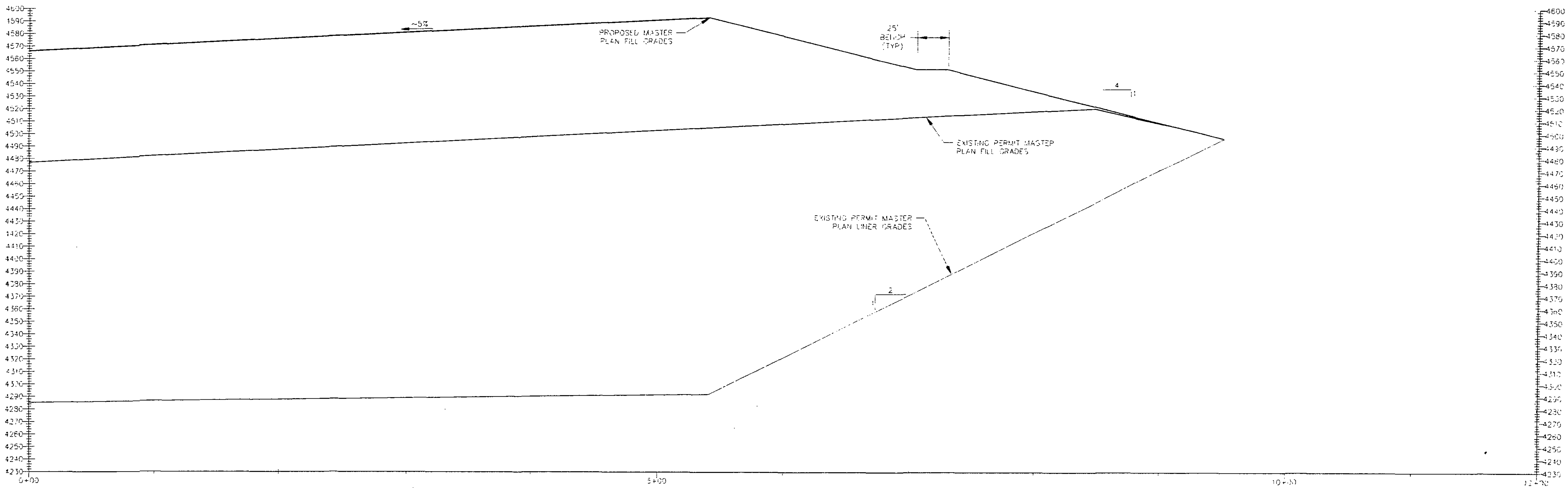
PERMIT DRAWING



SECTION A-A'

1" = 40'

B03 | B04



SECTION B-B'

1" = 40'

B03 | B04

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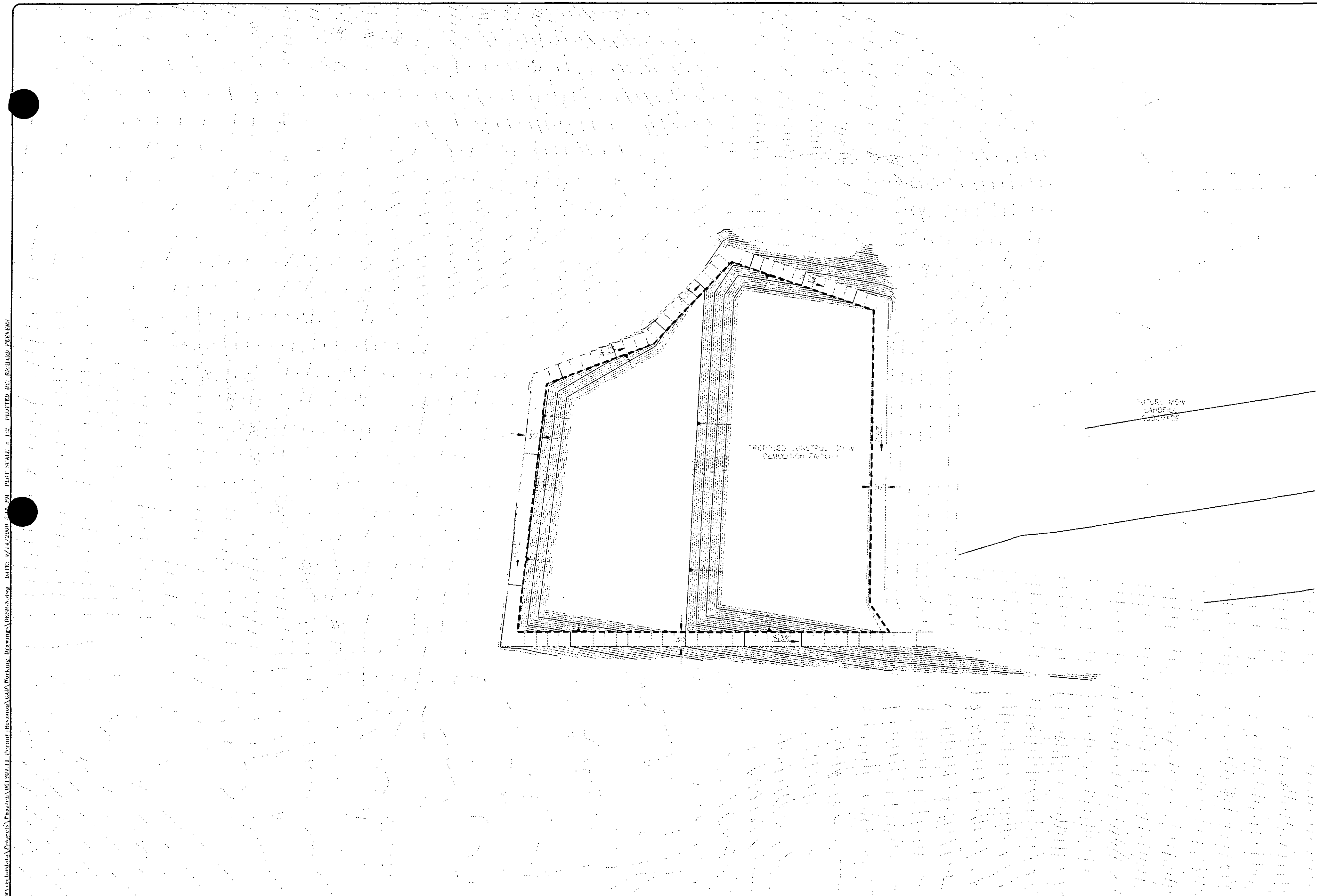
WASATCH REGIONAL LANDFILL, INC.

WASATCH REGIONAL LANDFILL
PERMIT REVISION
TOOELE COUNTY, UTAH
CROSS SECTIONS

FIGURE NO. 4
PROJECT NO. 061204.11

PERMIT DRAWING



GRAPHIC SCALE

LEGEND

- EXISTING 10 FT CONTOUR
- EXISTING 2 FT CONTOUR
- FUTURE 10 FT SUBGRADE CONTOUR
- FUTURE 2 FT SUBGRADE CONTOUR
- C&D FACILITY LIMITS

QUANTITIES

REV. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 07/30/2008
DESIGNED BY: JVR
DRAWN BY: RPR
CHECKED BY: JVR
APPROVED BY: JVR

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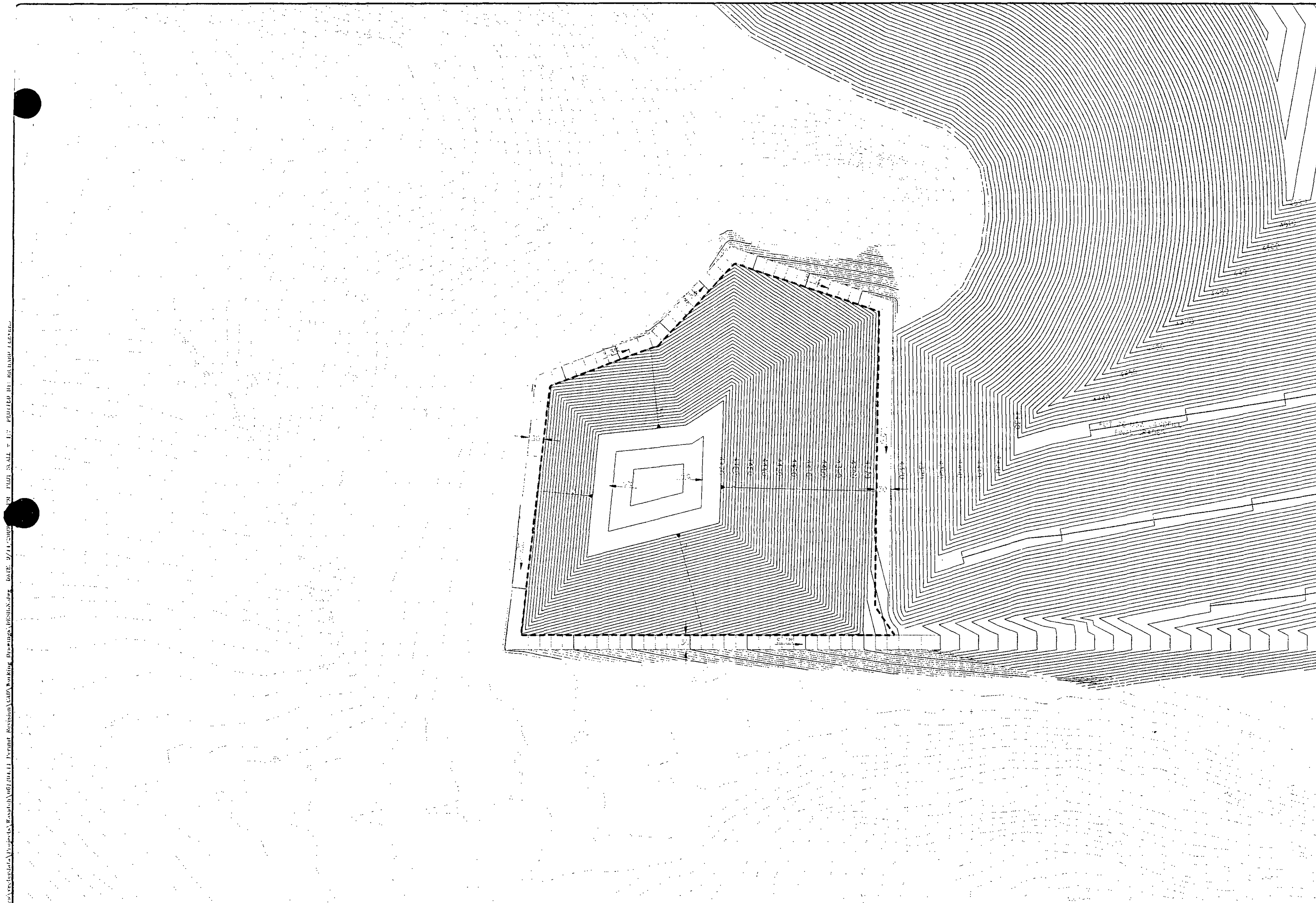
WASATCH REGIONAL LANDFILL, INC.

WASATCH REGIONAL LANDFILL
PERMIT REVISION
TOOELE COUNTY, UTAH
C&D FACILITY SUBGRADE PLAN

FIGURE NO. 5
PROJECT NO. 061204.11

This drawing has not been published but rather has been prepared by Vector Engineering, Inc. for use by the client named in the title block, solely in respect of the construction operation, and maintenance of the facility named in the title block. Vector Engineering, Inc. shall not be liable for the use of this drawing on any other facility or for any other purpose.

PERMIT DRAWING



GRAPHIC SCALE

LEGEND

EXISTING 2 FT CONTOUR

FUTURE FINAL 10 FT COVER CONTOUR

QUANTITIES

REV. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 07/30/2008
DESIGNED BY: JVR
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TOOELE COUNTY, UTAH
C&D FACILITY FINAL COVER GRADE

FIGURE NO. 6
PROJECT NO. 061204.11

PERMIT DRAWING

WASTE FILL STABILITY EVALUATION
of the
WASATCH REGIONAL LANDFILL
Toole County, Utah

Prepared for:
ALLIED WASTE INDUSTRIES, INC.
111 West Highway 123
East Carbon, Utah

Prepared by:

VECTOR
ENGINEERING, INC.
An Ausenco group company
143E Spring Hill Drive
Grass Valley, California 95945
(530) 272-2448

Project No. 061204.11
February 2009

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this analysis was to evaluate the slope stability for a 100-ft increase in maximum waste height at the Wasatch Regional Landfill (WRL), located in Tooele County, Utah. The stability evaluation was performed by Vector Engineering, Inc. (Vector), and is summarized in this report.

1.2 Scope of Work

Vector's scope of work included conducting a soils investigation in 2006 and an evaluation of the final liner system options and waste fill configurations for the WRL. Slope stability analyses were performed to ensure the static and pseudo-static stability of the system, and included the following critical design elements:

1. An increase in the top deck elevation of the landfill by 100 feet, which would raise the maximum waste elevation to 4,620 feet.
2. A maximum overall waste slope of 4 horizontal to 1 vertical (4H:1V), with a top deck slope of approximately 5%.
3. Side slopes lined with textured geomembrane and high-strength geosynthetic clay liner (GCL).
4. A floor-liner system comprised of GCL, either smooth or textured geomembrane, and a geocomposite.

The work tasks performed for this study included the following:

1. *Laboratory Testing.* Large Scale Direct Shear (LSDS) tests for several liner system configurations were performed in October 2006, May 2007, and April 2008. All laboratory testing was conducted by Vector in Grass Valley, California.
2. *Seismic Hazard Evaluation.* Historic, deterministic, and probabilistic analyses were performed to evaluate the site specific seismic risks and potential slope stability hazards.
3. *Slope Stability Analyses.* Limit-equilibrium slope stability analyses were performed for an idealized cross section of the landfill. Infinite Slope stability analyses were performed on the final cover system. Slope stability was evaluated for static and pseudo-static (earthquake) conditions.

4. *Displacement Analyses.* Based on the results of the pseudo-static stability analyses, potential displacements were estimated for the design earthquake magnitude.
5. *Report Preparation.* This report summarizes the results and conclusions for each of the tasks listed above.

1.3 Location and General Description

The WRL is located at 8833 North Rowley Road, North Skull Valley, Utah; west of the Great Salt Lake and adjacent to the east side of the Lakeside Mountain Range in Tooele County. The WRL will consist of eleven phases covering approximately 793 acres and will have an ultimate capacity of approximately 160 million cubic yards.

The site climate is arid with an average annual rainfall of 12.9 inches. Maximum precipitation months are March, April and May, whereas June, July and August are the drier season. In addition, the site receives an average annual snowfall depth of 33.5 inches (Western Regional Climate Center).

In the final configuration, the waste slopes will be graded at a maximum slope of 4H:1V in between benches, with a top deck slope of approximately 5 percent. The slope will have benches that are approximately 25 feet wide. The highest slope is located on the east side of the landfill running in a north-south direction, having a vertical slope height of approximately 200 ft. The expansion will have a liner and a leachate collection system as well, and therefore, a leachate mound is not expected to develop within the landfill and was not included in the analyses. The critical landfill cross-sections used for the stability analyses are shown in Appendix D.

The side-slope liner system consists of the following elements (from bottom to top):

- Prepared subgrade;
- Reinforced GCL installed over the prepared subgrade;

- 60-mil double textured HDPE geomembrane covering the GCL; and
- A 2-ft thick layer of protective soil cover.

Two different options for the floor liner system were analyzed. The elements of floor liner system OPTION 1 included (from bottom to top):

- Prepared subgrade;
- Non-reinforced GCL installed over the prepared subgrade;
- 60-mil smooth HDPE geomembrane covering the GCL;
- Single sided geocomposite drainage layer over the geomembrane; and
- A 2-ft thick layer of protective soil cover.

The elements of floor liner system OPTION 2 included (from bottom to top):

- Non-reinforced GCL installed over the prepared subgrade;
- 60-mil double sided textured HDPE geomembrane covering the GCL;
- Single sided geocomposite drainage layer over the geomembrane; and
- A 2-ft thick layer of protective soil cover.

2.0 SUBSURFACE INVESTIGATION AND CONDITIONS

2.1 Field Investigation

Previous geotechnical investigations for the WRL were conducted by AGEC (2004, 2005) and Kleinfelder (2004). In addition, Vector conducted logging and sampling of four soils from test pits excavated in 2006. Classification tests were performed for the samples, including initial moisture (ASTM D-2216), particle size analysis (ASTM D-422), and Atterberg limits (ASTM D-4318).

2.2 Laboratory Testing

For the purpose of this study, additional laboratory testing was performed by Vector in April 2008. LSDS tests were completed to obtain shear strength properties for the following interfaces: GCL vs. Double Textured HDPE, GCL vs. Smooth HDPE, Single Sided Textile Geocomposite vs. Smooth HDPE, GCL vs. GCL and Double Textured HDPE vs. GCL. All of the laboratory test results are presented in Appendix A.

2.3 Subsurface Conditions

Subsurface information presented within this report was obtained from the Geotechnical Investigation Permit Modification prepared by AGEC (2004) for the WRL. Subsurface conditions at the site were characterized by exploratory borings drilled by AGEC and the subsurface information reported by Kleinfelder and Vector. The subsurface profile generally consists of clay, silt and fine sand on the lower elevation portions of the site, with coarser grained materials present at higher elevations. Limestone bedrock was encountered in boring B-1 (AGEC, Dec. 2004) at a depth of 143 ft. Boring B-1 is located at local coordinates North 7,479,138.81 and East 1,293,915.65 (AGEC, Dec. 2004). The clay at the site is interlayered with sandy silt and occasionally silty sand. The clay is stiff to very stiff, slightly moist to moist, and brownish gray in color. The silty clay is gray in color, and medium stiff to soft. The silty sand contains occasional lean clay layers and ranges from loose to dense. The sandy gravel is silty and clayey, but contains occasional cobbles and boulders, and ranges from medium to very dense.

3.0 GEOLOGIC SETTING AND SITE GEOLOGY

3.1 Geologic Setting

The WRL is located in the Basin and Range Geomorphic province, which is characterized by horst and graben structure (subparallel, fault-bounded ranges separated by downdropped basins). This portion of the Basin and Range is within the Great Basin province, characterized by interior drainage with lakes and playas. The Basin and Range began extension during the Miocene. Many of the ranges are bounded by high-angle normal faults.

The exposed bedrock within the ranges in this portion of the Great Basin is predominantly Precambrian and Paleozoic marine carbonate and clastic sedimentary rocks (limestone, dolomite, shale, sandstones) with subordinate amounts of Tertiary volcanics. The intervening valleys within the Basin and Range are composed of alluvial, lacustrine and volcanic materials as much as 8,000 feet thick that have been deposited more-or-less continuously since the Miocene (within the last 15 million years).

During Late Pleistocene time, Lake Bonneville formed in western Utah and reached its highest level approximately 15,000 to 20,000 years ago. Lake Bonneville reached a maximum depth of over 1,000 feet, which resulted in many of the ranges in the area becoming islands. Since that time, Lake Bonneville has been shrinking to the size of the Great Salt Lake.

3.2 Site Geology

The WRL is located on the eastern edge of the Lakeside Mountains. These mountains are oriented north-south and are a northern extension of the Cedar Mountains. The Great Salt Lake shoreline is approximately 2.5 miles east of the Site. According to Hintze et al. (2000), the site is underlain by lacustrine sediments that were deposited during the Late Pleistocene when the surface of Lake Bonneville was about 900 feet above the site.

The Lakeside Mountains west of the site are composed of Paleozoic marine sedimentary rocks folded into a syncline plunging to the southeast. The core of the syncline contains Mississippian aged Woodman Formation and/or Ochre Mountain Limestone with the northern limb of the syncline containing Ordovician through Devonian age dolomites, limestones, shales and sandstones. The outcrops immediately west of the site are part of the Devonian section. The southern limb of the syncline has been largely faulted away, with Pennsylvanian to Permian rocks exposed on the south side of the fault.

Below the lacustrine sediments that underlie the site, bedrock is likely to exist at a relatively shallow depth along a peneplane as evidenced by small presumably bedrock knobs east of the site.

4.0 FAULTING, SEISMOLOGY & EARTHQUAKE GROUND MOTION

Deterministic seismic hazard analyses were conducted for 12 fault sources within a 160 km radius of the WRL to provide the potential ground motion seismic evaluation of the waste fill stability.

4.1 Local and Regional Faulting

The WRL is located approximately 72 km west from the Wasatch Front area, which is a seismically active region having only moderate historical seismicity, but high catastrophic potential from future large earthquakes. The Wasatch Fault is one of the longest and most tectonically active normal faults in North America which slips in a primarily vertical direction, with the mountains rising relative to the valley floor. The fault zone shows abundant evidence of recurrent Holocene surface faulting and has been the subject of detailed studies for over three decades. This fault has 10 sections where the southern 8 sections are entirely in Utah. The nearly 350-km-long Wasatch fault zone has traditionally been divided into seismogenic segments that are thought to behave at least somewhat independently. The chronology of surface-faulting earthquakes on the fault is one of the better dated in the world, and includes 16 earthquakes within the last 5,600 years, with an average repeat time of 350 years. Four of the central five sections ruptured between 600 and 1,250 years ago; whereas the next section to the north has not ruptured in the past 2,125 years. Slip rates of 1-2 mm/yr are typical for the central sections during Holocene time. In contrast, middle and late Quaternary (<150-250 ka) slip rates on these sections are about an order of magnitude lower.

The closest fault which U.S. Geological Survey (USGS) indicates as active during the Latest Quaternary (within the last 15,000 years) is the west side of Stansbury Fault which is located approximately 14 km south of the site. The Stansbury Fault is located along the western side of the Stansbury Mountains. This is a generally north-trending normal fault zone bounding the western side of the Stansbury

Mountains. The Stansbury Mountains expose mainly Paleozoic rock, and are the centermost of three prominent north-south mountain ranges (including the Oquirrh Mountains to the east and Cedar Mountains to the west) west of the high central part of the Wasatch Range. Surficial geology in the valleys between the ranges is dominated by lake deposits and alluvium. The USGS describes the Stansbury Fault as a normal fault with latest activity occurring in Holocene to Late Quaternary time with a slip rate of less than approximately 0.2 mm/yr.

4.2 Historical Seismicity

As early as 1883, geologists recognized and warned of the serious earthquake threat posed by the Wasatch Fault and other active faults in Utah despite the absence, up to that time, of any large earthquakes in the region. A search of historical earthquakes occurring between 1800 and 2008, listed in the USGS catalog, was performed for a 160 km radius around the project site. That search found that 605 earthquakes occurred within that area during that 208-year period. Of those earthquakes, 11 have moment magnitudes (Mw) of 5 or greater, and 3 have Mw of 6 to 6.8.

The largest recorded near-source earthquake to affect the area within a 160 km radius was an Mw 6.8 that occurred on March 12, 1934, approximately 74 km from the project site. According to USGS, the closest historical earthquake to affect the site was an Mw 5.2 event that occurred approximately 35 km east of the site. The largest estimated site acceleration to affect the area within a 160 km radius occurred on March 12, 1934 and March 28, 1975. These events were located approximately 74 km and 135 km, respectively, from the project site. Table 1 summarizes the peak horizontal acceleration of the mentioned historical earthquakes at the site, according to various attenuation relationships.

TABLE 1
SUMMARY OF PEAK HORIZONTAL ACCELERATIONS FOR HISTORICAL EARTHQUAKES

EARTHQUAKE MAGNITUDE (Mw)	DATE OF EVENT	DISTANCE FROM SITE (km)	PEAK HORIZONTAL ACCELERATION (G)			
			BOORE ET AL. (1993)	TORO ET AL. (1995)	YOUNGS ET AL. (1988)	AVERAGE PEAK HORIZONTAL ACCELERATION (g)
5.2	Sept. 5, 1962	35	0.030	0.050	0.03	0.037
6.8	March 12,1934	74	0.079	0.100	0.12	0.100
5.1	March 12, 1934	74	0.000	0.000	0.01	0.000
6.1	March 12, 1934	74	0.040	0.075	0.03	0.048
5.3	April 14, 1934	74	0.000	0.000	0.00	0.000
5.5	May 6, 1934	74	0.040	0.070	0.05	0.053
5	May 24, 1980	120	0.000	0.000	0.00	0.000
5.5	April 7, 1934	127	0.010	0.100	0.03	0.047
6.8	March 28, 1975	135	0.045	0.100	0.06	0.068
5.7	Aug. 30, 1962	157	0.01	0.06	0.01	0.036

4.3 Deterministic Estimates of Strong Ground Motions

Peak horizontal ground accelerations were estimated for the project site using the attenuation relationship from Idriss (1991). A search was conducted for all earthquake sources within a 160 km radius of the project site which are believed to be active during Holocene time (the last 10,000 years). The activity and location of the faults was based on information from the USGS. From this search, it was determined that there are 72 earthquake sources which are believed to be active within a 100-mile radius of the site. The results of the deterministic estimates for the 12 earthquakes with the highest estimated Peak Ground Acceleration (PGA) are shown in Table 2. A more comprehensive list of earthquake sources is presented in Appendix B.

TABLE 2
DETERMINISTIC GROUND MOTION DATA

FAULT NAME	UPPER BOUND EARTHQUAKE (M_W)	DISTANCE FROM SITE (km)	APPROXIMATE FAULT DATA		DETERMINISTICALLY ESTIMATED PEAK GROUND ACCELERATION (G)
			LENGTH (Km)	SLIP RATE (MM/YR)[A]	M [B]
Stansbury fault zone	6.9	14	50	less than 0.2	0.436
Skull Valley (mid-valley) faults	6.9	35	55	less than 0.2	0.182
Puddle Valley fault zone	6.1	24	7	less than 0.2	0.136
Oquirrh fault zone	7.0	47	21	0.2 to 1	0.135
East Great Salt Lake fault zone, Promontory section	6.8	48	37	0.2 to 1	0.121
East Great Salt Lake fault zone, Antelope Island section	6.6	40	26	0.2 to 1	0.110
Southern Oquirrh Mountains fault zone	7.1	58	24	0.2 to 1	0.109
East Great Salt Lake fault zone, Fremont Island section	6.3	40	13	0.2 to 1	0.086
Wasatch fault zone, Salt Lake City section	7.1	72	23	1 to 5	0.083
Wasatch fault zone, Weber section	7.0	72	20	1 to 5	0.079
Wasatch fault zone, Clarkston Mountain section	7.3	80	43	less than 0.2	0.079
Wasatch fault zone, Provo section	7.1	80	23	1 to 5	0.072

[A] From USGS
[B] M = indicates estimated mean peak horizontal ground acceleration from Idriss (1991).

Based on these evaluations, the site could be subjected to horizontal ground accelerations as high as 0.436 g from the rupture along the Stansbury Fault. The Stansbury Fault zone is located about 14 km south of the site. It should be noted that probability and exposure periods are not considered during deterministic evaluations and that, typically, deterministic estimates of strong ground motion for a site generate relatively conservative horizontal ground acceleration values.

4.4 Probabilistic Estimates of Strong Ground Motion and Peak Ground Acceleration

Probabilistic evaluations of horizontal ground motions that could affect the site were performed using the USGS *Java Ground Motion Parameter Calculator – Version 5.0.8.* This application includes hazard curves, uniform hazard response spectra, and design parameters for sites in the 50 states of the United States, Puerto Rico, and the U.S. Virgin Islands. Parameters were searchable with the latitude and longitude data of the WRL, which are approximately 40.85 latitude and -112.75 longitude. The application was used to obtain uniform hazard response spectra for 2% probability of exceedance in 50 years and 10% probability of exceedance in 50 years. Table 3 summarizes the probabilistic ground motion data for the WRL.

TABLE 3
PROBABILISTIC GROUND MOTION DATA

PROBABILISTIC ESTIMATE EXPOSURE PERIOD (YEARS)	PROBABILITY OF EXCEEDANCE (%)	RETURN PERIOD (YEARS)	ESTIMATED PEAK HORIZONTAL GROUND ACCELERATION (G)
50	10	477	0.211
50	2	228	0.435

4.5 Design Basis Earthquake Event

Historically, the site experienced an estimated acceleration of 0.10 g during the event of March 12, 1934, which was the most critical for the site. Based on the risks associated with the Stansbury Fault, a site acceleration of 0.436 g is considered possible. From the probabilistic evaluation, a peak horizontal ground acceleration of 0.435 g was estimated for a 2% probability of exceedance in a 50 year exposure period.

Seed (1979) suggested that to ensure that displacements will be acceptably small, it is only necessary to perform a pseudo-static screening analysis for a seismic coefficient of 0.1 g for earthquakes up to a magnitude 6.5 or 0.15 g for earthquakes up to a magnitude 8.5, and obtain a factor of safety of 1.15 or greater. This procedure is only acceptable for site soils that are not vulnerable to excessive strength loss or pore pressure development. Both field and laboratory experience indicate that clayey soils, dry sands and in some cases dense saturated sands will not lose substantial resistance to deformation as a result of earthquake loading (Seed, 1979).

As described previously, the WRL subsurface consists mainly of clays, silts and fine sand at the lower elevation portions of the site, with more granular material at the higher elevation portions. Based on the Geotechnical Investigation Permit Modification prepared by AGEC (2004), water was encountered in the deeper borings at an approximate elevation of 4,220 ft to 4,335 ft (approximately 100 ft below the surface). These site subsurface conditions indicate that significant pore pressure generation is not a concern, and that Seed's (1979) procedure can be applied as an acceptable method of ensuring adequate performance for the WRL.

Based on the seismic hazard analyses and on Seed's (1979) procedure, the design earthquake we have chosen for this site would be from a magnitude 6.9 event on the

Stansbury fault. Therefore, a site horizontal seismic coefficient, k_h, of 0.15g was chosen based on Seed (1979) to be used as a pseudo-static screening value.

5.0 STABILITY ANALYSIS

5.1 General

Vector conducted stability analyses for the WRL for both static and pseudo-static conditions. Pseudo-static analyses were performed to determine the pseudo-static screening factor of safety and the yield acceleration for the slope condition analyzed. Failure surfaces through the waste and along the geomembrane liner were evaluated to determine the factor of safety for slope stability. Cross-section A-A' is located in the northern portion of the WRL, as shown on Figure 3 in the drawings. This section was chosen to present the most critical slope for the slope stability analyses. The analyzed cross section is presented in Appendix D.

The computer program SLIDE 5, developed by Rocscience, Inc (2003), was used for the analyses to determine the factors of safety and probabilities of failure. Spencer's Method of slices was used in the analysis to obtain the factor of safety. The factor of safety can be defined generally as the resisting forces divided by the driving forces. A factor of safety of 1.0 or less indicates that the slope is potentially unstable. Several search routines were used to evaluate tens of thousands of potential failure surfaces for each case analyzed.

Both static and pseudo-static analyses were performed for circular and non-circular surfaces. The pseudo-static analyses subject the two-dimensional sliding mass to a horizontal acceleration equal to a horizontal earthquake coefficient, k_h, multiplied by the acceleration of gravity. As described in section 4.5, a k_h of 0.15 was used as a screening tool for the slope stability evaluation of the WRL.

An infinite slope analysis was conducted for the proposed 2.5-foot thick Evapotranspirative (ET) cover system, to be constructed with "soil #2" material (see Vector Engineering report "Evaportranspirative (ET) Final Cover Permitting Report," 2006) for the 4H:1V side slopes. The Infinite Slope Method is commonly used for landfill cover analyses, and can incorporate the effects of landfill gas pressure, water buildup, and seismic events. A friction angle of 30 degrees was assumed for the cover soil based on laboratory strength test data (AGEC, 2004) with no adhesion. No landfill gas pressure was assumed because of the nature of the ET cover system. The infinite slope stability analyses method can account for the affects of cover soil saturation, as this can often cause cover systems to fail. The ET cover system proposed for this site is designed to remain partially saturated and is not intended to become fully saturated. A peak horizontal ground acceleration of 0.15 g was used for the Seed (1979) screening procedure, to determine if displacement analyses were required, as detailed in section 4.5 of this report.

5.2 Material Properties

The material properties of the various components of the landfill needed to perform static and pseudo-static slope stability analyses (e.g. unit weight and shear strength parameters) were obtained from the literature (Mitchell et al. 1992) and the previously performed interface shear testing. Table 4 shows a summary of the material properties used for the analyses.

TABLE 4
SUMMARY OF MATERIAL PROPERTIES USED IN STABILITY ANALYSES

SLOPE LINER SYSTEM	ANALYZED CRITICAL INTERFACE	TOTAL UNIT WEIGHT (PCF)	COHESION (PSF)	INTERNAL ANGLE OF FRICTION (DEGREES)
	Compacted Fill (Subgrade)	120	40	31
	Municipal Solid Waste (MSW)	65	100	30
Side Slope Liner GCL vs. Double Textured HDPE Geomembrane	Textured HDPE Geomembrane/ GCL	100	226[A]	14[A]
Floor Liner - Option 1 GCL vs. Double Smooth HDPE Geomembrane vs. Single Sided Geocomposite	Smooth HDPE Geomembrane/ Single Sided Geocomposite	100	20[A]	12[A]

SLOPE LINER SYSTEM	ANALYZED CRITICAL INTERFACE	TOTAL UNIT WEIGHT (PCF)	COHESION (PSF)	INTERNAL ANGLE OF FRICTION (DEGREES)
Floor Liner – Option 2 GCL vs. Double Textured HDPE Geomembrane vs. Single Sided Geocomposite	Textured HDPE Geomembrane / Single Sided Geocomposite	100	60[A]	15[A]
ET Final Cover *4H:1V Side Slopes*	Compacted Fill (ET cover)	100	0	30

A – From statistical analysis based on typical laboratory test results from similar liner interfaces.

5.3 Probabilistic Analysis

Variations in the strength parameters (i.e. cohesion and friction angle) can compromise the stability of the slopes. Slope stability analyses using worst-case strength parameters results in an overly conservative design. However, using mean strength parameters may result in an artificially high FOS. The probabilistic approach defines a range and statistical distribution for the soil strength parameters and densities used in the slope stability analyses. For each slip surface analyzed, a distribution of calculated safety factors is determined and a probability of failure is calculated. This approach accounts for the variability of the soil properties within the slope as shown in the field and laboratory test data.

The computer program SLIDE 5 (Rocscience, 2008) uses statistical distributions (i.e. Normal, Log Normal, Exponential, etc.) to model the variation in material properties in order to develop a Probability of Failure (PF) for a slope. For the WRL slope stability analyses, limited information was known about the shear strength of the geosynthetic/soil interface. From past experiences with similar interfaces, we selected the "most likely" shear strength properties for the interface at WRL. These properties were selected as the mean values for normally distributed data sets. The normal probability distribution function insures that 68% of the random values Slide selects for the shear strength properties of the interface, should fall within one standard deviation and the mean, and 95% of the random values should fall within two standard deviations of the mean. Standards of deviation for each of the material properties were determined from a database of strength tests on similar interfaces. Table 5 below summarizes the probabilistic material properties used for our analyses.

TABLE 5
SUMMARY OF PROPERTIES USED FOR PROBABILISTIC STABILITY ANALYSIS

MATERIAL	PROPERTY	DISTRIBUTION	MEAN	STD. DEV.	MIN	MAX
Interface	Cohesion (psf)	Normal	60	211	0	410
Interface	Phi (deg)	Normal	15	7	9	23

5.3 Results of the Stability Analyses

Circular and non-circular surfaces along the waste and liner interface, respectively, were evaluated using Spencer's method as well as a probabilistic approach. For the probabilistic slope stability analysis, statistical distributions to the model material properties (input parameters), such as cohesion and angle of friction, were assigned. These parameter values were based on laboratory test results for similar interfaces from tests conducted by Vector at our laboratory in Grass Valley, CA. This allowed the analyses to account for a degree of uncertainty in the cohesion and friction angle values for the geosynthetic interfaces.

The results of the stability analyses are summarized in Table 5. The critical failure surfaces originated near the toe of the waste slopes and day-lighted near the crest. The output presents the material properties, and locations of the critical shear surfaces with the lowest factor of safety (see Appendix D). The minimum factor of safety calculated in the pseudo-static analyses for the two liner system options was 0.91. Based on these results, seismic displacement analyses were performed.

The yield acceleration (k_y) of the landfill mass was calculated for both liner system configurations. The yield acceleration is defined as the horizontal acceleration that, when applied to the slope in the limit equilibrium (seismic) analyses, results in a pseudo-static factor of safety equal to one. The yield acceleration was determined using the Spencer method and the results are shown in Table 5. The output files from SLIDE 5 for these analyses are included in Appendix D.

The static factors of safety for the infinite slope stability analyses were between 2.8 and 3.0, meeting the accepted 1.5 FOS standard for lined MSW landfills. The pseudo-static (earthquake) factors of safety were between 1.7 and 1.8, greater than the 1.15 screening FOS specified by the Spencer (1979) procedure. The cover stability analysis and results are included in Appendix D.

TABLE 6
SUMMARY OF SLOPE STABILITY RESULTS FOR CROSS *SECTION A-A'*

	CASE ANALYZED	STATIC FACTOR OF SAFETY	STATIC PROBABILITY OF FAILURE (%)	PSEUDO-STATIC FACTOR OF SAFETY (K_h=0.15)	YIELD ACCEL. (Ky)
Non Circular Analysis	*Option 1* Smooth HDPE Geomembrane/ Single Sided Geocomposite	1.70	< 1	0.91	0.123
	Option 2 Textured HDPE / Single Sided Geocomposite	1.99	< 1	1.09	0.175
Circular Analysis	*Option 1* Smooth HDPE Geomembrane/ Single Sided Geocomposite	2.773	<1	1.58	0.34
	Option 2 Textured HDPE / Single Sided Geocomposite	2.829	<1	1.61	0.35
Infinite Slope Analysis	*2.5' ET Cover System* 4H:1V side slopes	2.31	<1	1.39	0.29

NOTE: Both liner configuration options have the same side slope liner system (Textured HDPE Geomembrane vs. GCL) properties as well as the MSW and the subgrade properties.

5.4 Conclusions Regarding Slope Stability

A factor of safety equal to or greater than 1.50 and 1.15 is generally considered acceptable for static conditions and pseudo-static conditions, respectively. Under static conditions the section analyzed showed an acceptable factor of safety for all liner configuration options. However, during an earthquake, displacement is possible since the pseudo-static factor of safety was less than 1.15 in both liner configurations. Therefore, a displacement analysis was performed, as discussed in the next section, to determine the potential displacement of the waste mass. The seismic stability analyses of the final cover system resulted in a FOS greater than 1.15, indicating that significant deformations in the final cover are not expected during the design earthquake.

6.0 SEISMIC DISPLACEMENT ANALYSIS

6.1 General

Seismic displacement analyses were performed for cross-section A-A' to evaluate the permanent displacements which may occur during an earthquake. The method chosen for the analyses was the "Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills" by Bray et al. (1998). This method uses chart solutions to estimate the displacement for earthquake accelerations which are greater than the yield acceleration. The design earthquake would have a magnitude of 6.9. Based on the earthquake hazard analyses, the design site acceleration would be from a near field event on the Stansbury Fault zone. This event would result in a peak horizontal ground acceleration (PHGA) of 0.436 g at the site. In theory, the landfill will displace during a seismic event when the site acceleration exceeds the yield acceleration. The yield acceleration for floor-liner Option 1 was 0.123 g. The yield acceleration for floor-liner Option 2 was 0.175 g. The analyses show that base sliding of the landfill during the design earthquake would result in top displacements for both options (1 and 2) would be less than 1. For lined landfills, displacements less than or equal to 12 inches are generally considered acceptable (Kavazanjian 1999).

7.0 CONCLUSIONS

Vector performed slope stability analyses for the WRL based on the conceptual design of the landfill, preliminary soils data and historical seismicity near the site. Circular and non-circular failure surfaces through the waste and the critical liner interface were evaluated to determine the factor of safety for stability. Infinite slope stability analyses were performed on the final cover system. For static conditions, the results of the stability analyses indicate that the landfill will remain stable for all liner system configurations and the final cover system. For the pseudo-static conditions, the factor of safety for slope stability drops below 1.15, and therefore, a displacement analysis was performed. The displacement estimated from the seismic analysis for the weaker liner condition (Option 1) ranged from 0.0 in. to 0.3 in., which is considered acceptable (Kavazanjian 1999). Displacements for Option 2 ranged from 0.0 in to 0.1 in. Pseudo-static analyses for the final cover system resulted in a FOS greater than 1.15 and significant deformations in the covers system are not expected.

8.0 LIMITATIONS

The recommendations presented in this report are based upon understanding of the project, a field investigation, and the information provided by WRL. This report was prepared in accordance with generally accepted soils and foundation engineering practices applicable at the time the report was prepared. Vector makes no other warranties, either expressed or implied, as to the professional opinions and conclusions provided.

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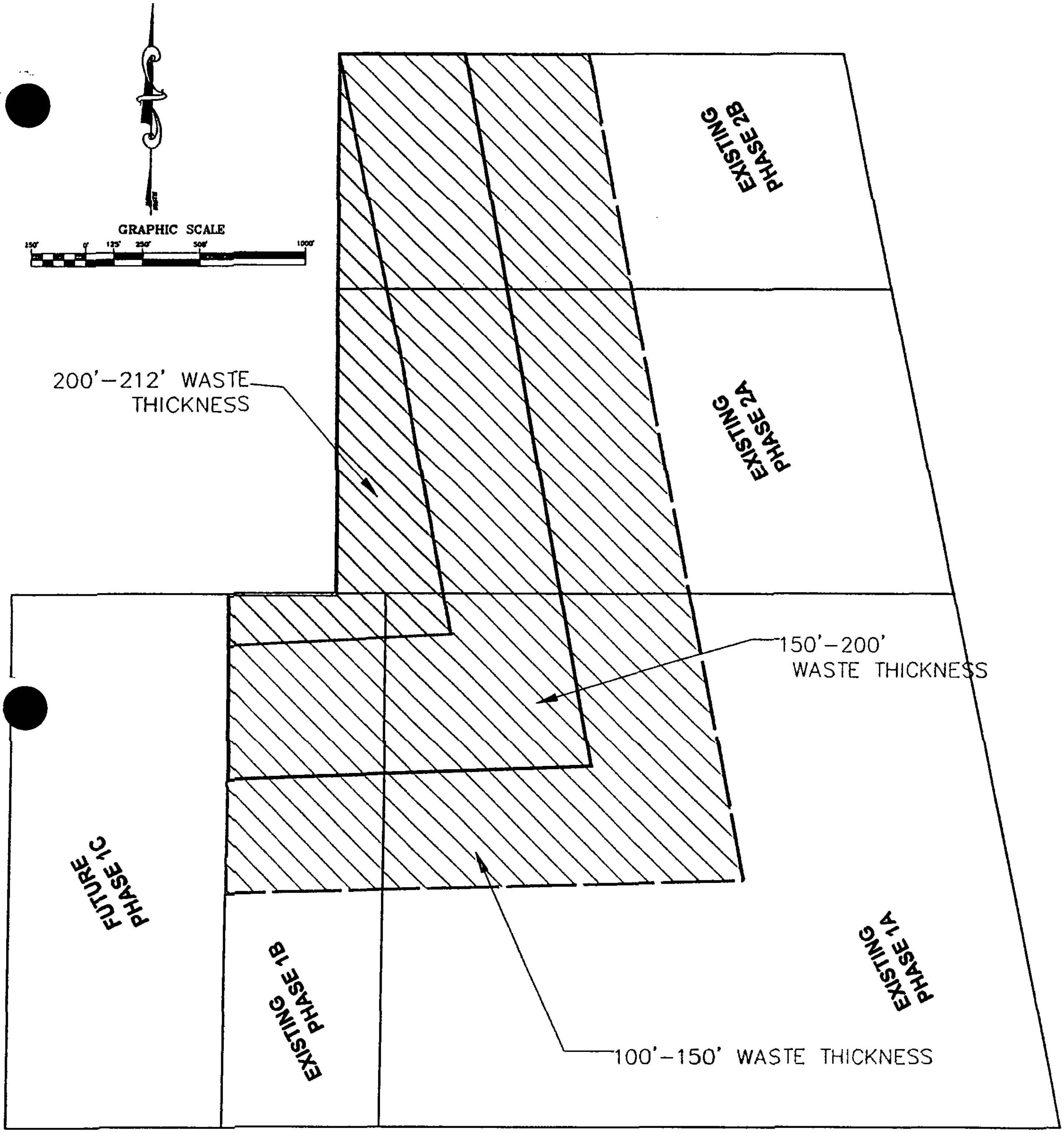


...E: 12/03/2008 ...SIGNED BY: DMW ...RAWN BY: DMW ...ECKED BY: JVR ...PROVED BY: JVR	VECTOR ENGINEERING, INC. An Ausenco group company THE AMERICAS • ASIA • AUSTRALIA 143E Spring Hill Drive, Grass Valley, CA 95945 +1-530-272-2448 +1-530-272-8533 fax	PERMIT MODIFICATION WASATCH REGIONAL LANDFILL ALLIED WASTE, INC. TOOELE, UTAH WASTE THICKNESS	DRAWING NO. 01 PROJECT NO. 041200.00

...drawing has not been published but rather has been prepared by Vector Engineering, Inc. for use by the client named ...he title block, solely in respect of the construction operation, and maintenance of the facility named in the title block.

APPENDIX A
LABORATORY TESTING

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243A

Report Date: September 28, 2006

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B Project No: 061204.02

Superstrate: ⇦ Drainage Layer

Material 1: ⇦ CETCO Bentomat GCL, Nonwoven side towards HDPE LSN: AJB Grip Board

Material 2: ⇨ GSE 60 mil HDPE Double textured, Roll# 108117461 LSN: AIT Clamped

Substrate: ⇨ Concrete Board

PEAK STRENGTH

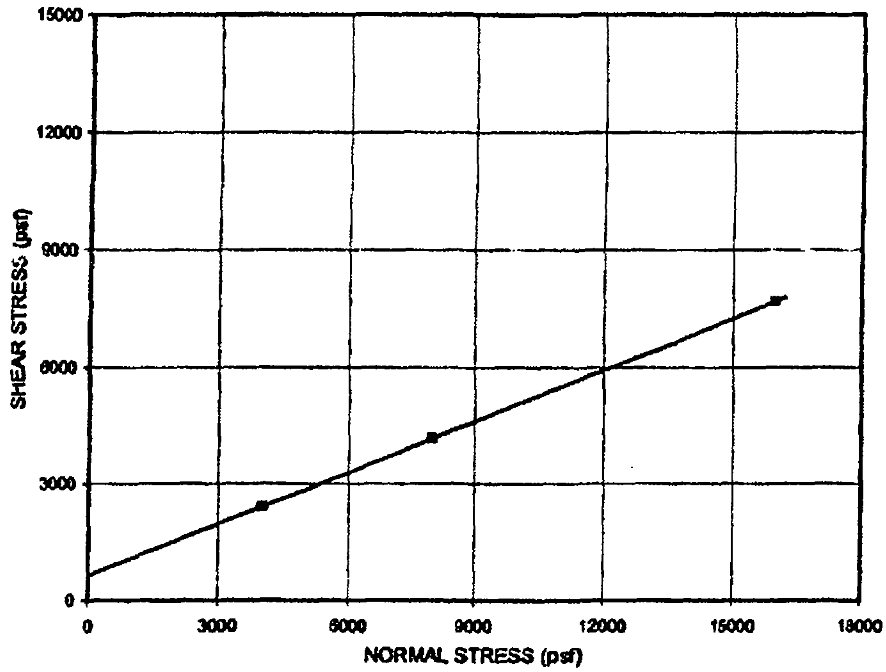
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	2400	31
2.	55.6	8000	4180	28
3.	111.1	16000	7680	26

Adhesion: 650 psf

Friction Angle: 24 degrees

Coefficient of Friction: 0.44

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 3.0 in. displacement)

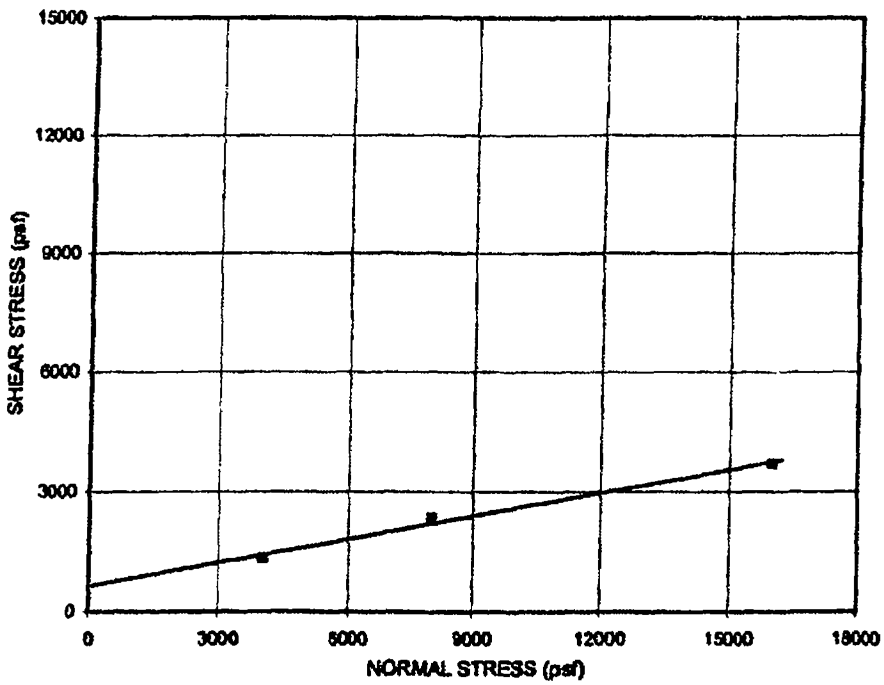
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	1320	18
2.	55.6	8000	2340	16
3.	111.1	16000	3700	13

Adhesion: 640 psf

Friction Angle: 11 degrees

Coefficient of Friction: 0.19

NOTE: GRAPH NOT TO SCALE



Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243A

Report Date: September 28, 200

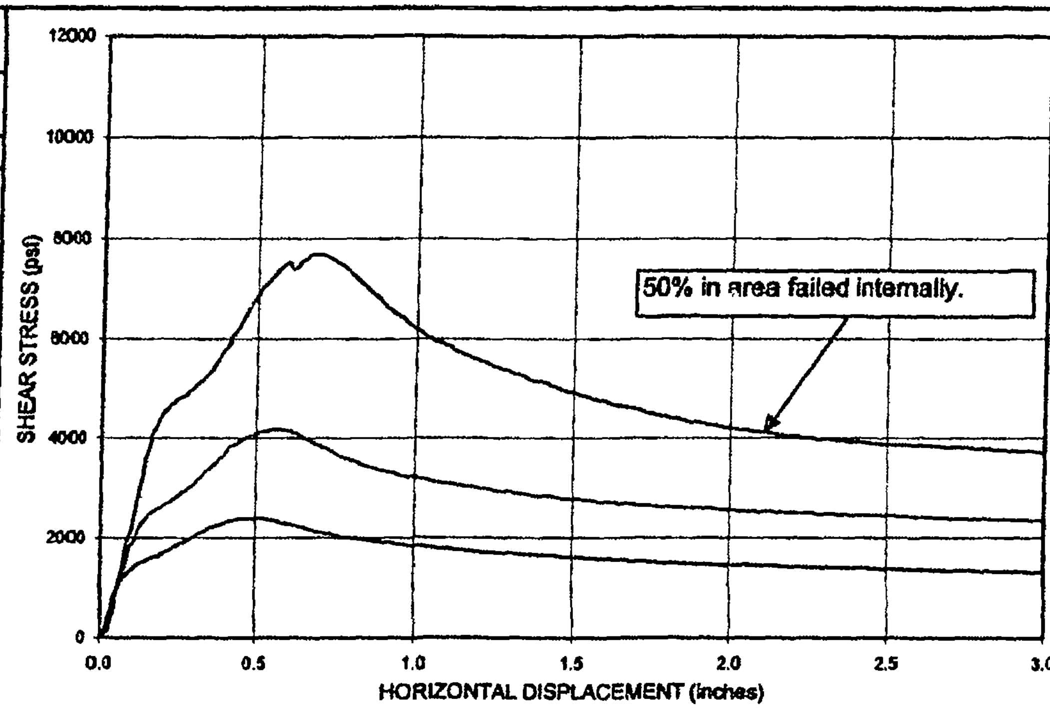
Project No: 061204.02

Client Name: ALLIED WASTE INC. Project Name: **WASATCH PHASE 1B**

Superstrate:	⟸ Drainage Layer		
Material 1:	⟸ CETCO Bentomat GCL, Nonwoven side towards HDPE	LSN: AJB	Grip Board
Material 2:	⟹ GSE 60 mil HDPE Double textured, Roll# 108117461	LSN: AIT	Clamped
Substrate:	⟹ Concrete Board		

DISPLACEMENT vs. SHEAR STRESS

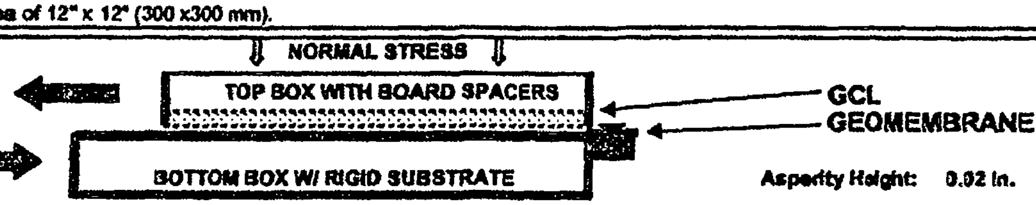
Test Point	*Normal Stress*	
	psi	*psf*
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000



STANDARD CONDITIONS: ***SHEAR DISPLACEMENT RATE: 0.04 in/min***

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



Asperity Height: 0.02 in.

SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of GCL was cut to 12" x 12", then placed on the geomembrane and gripped using a grip board.
3. Each test point was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the GCL and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243A

Report Date: September 28, 2006

Project No: 061204.02

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B

Superstrate: Drainage Layer

Material 1: GSE 60 mil HDPE Smooth, Roll# 108117338 LSN: AIP Clamped

Material 2: Claymax LSN: AJC Clamped

Substrate: Concrete Board

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	990	14
2.	55.6	8000	2060	14
3.	111.1	16000	4110	14

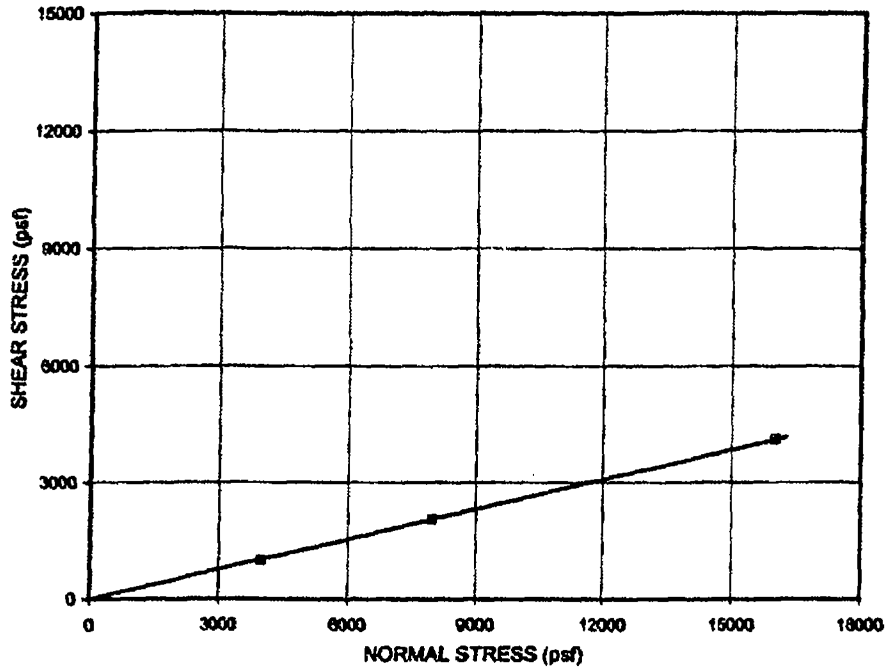
Adhesion: 0 psf

Friction Angle: 14 degrees

Coefficient of Friction: 0.26

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE
(at 3.0 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	610	9
2.	55.6	8000	1220	9
3.	111.1	16000	2530	9

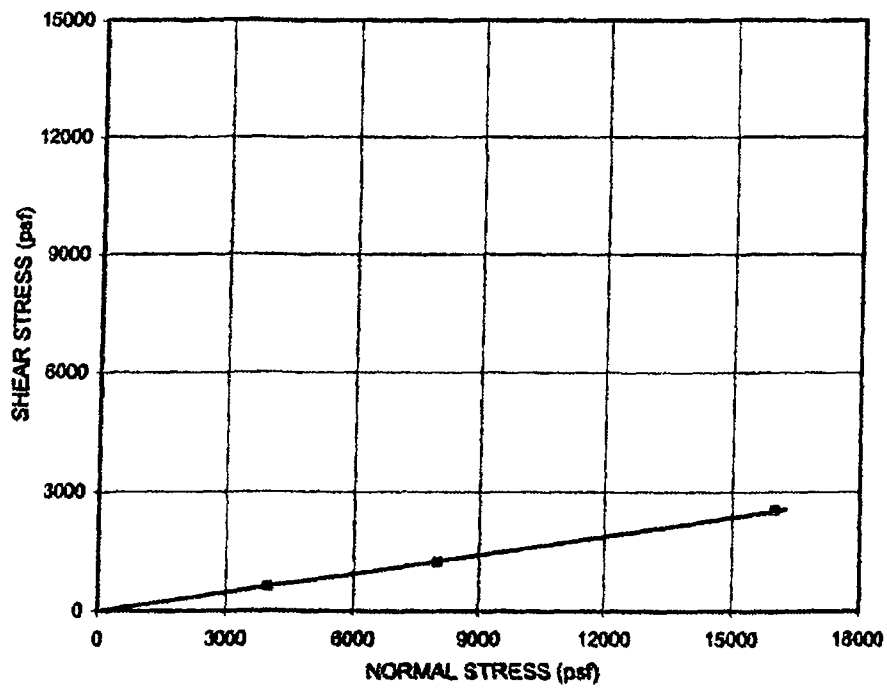
Adhesion: 0 psf

Friction Angle: 9 degrees

Coefficient of Friction: 0.16

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



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Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243A

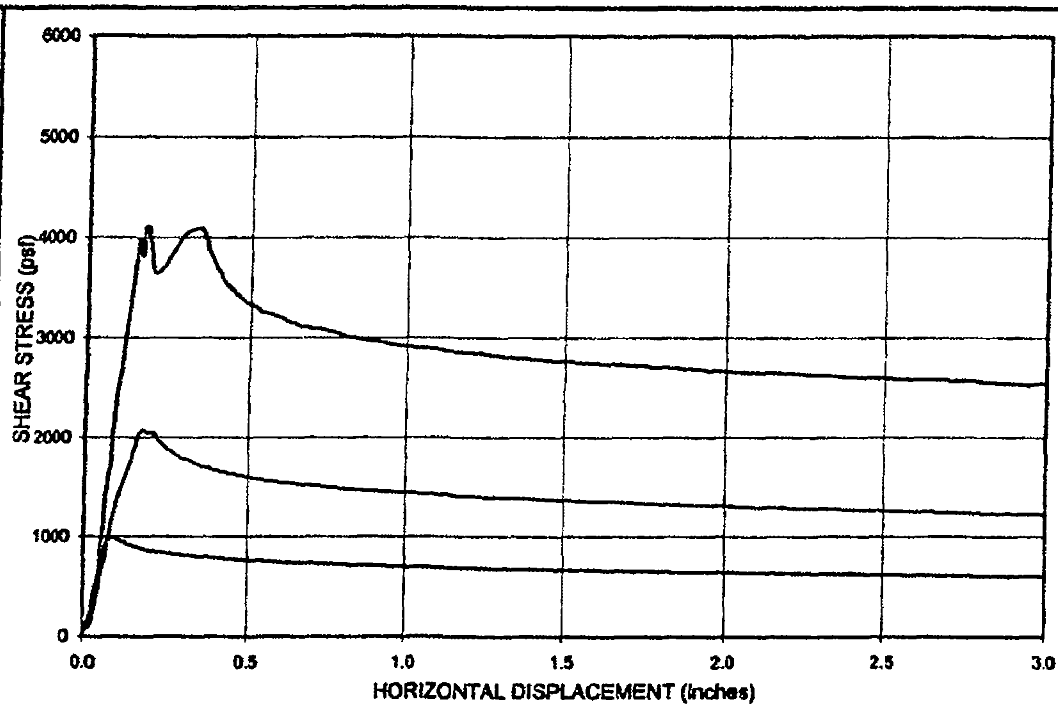
Report Date: September 28, 2006
Project No: 061204.02

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B

Superstrate:	Drainage Layer			
Material 1:	GSE 60 mil HDPE Smooth, Roll# 108117338	LSN:	AIP	Clamped
Material 2:	Claymax	LSN:	AJC	Clamped
Substrate:	Concrete Board			

DISPLACEMENT vs. SHEAR STRESS

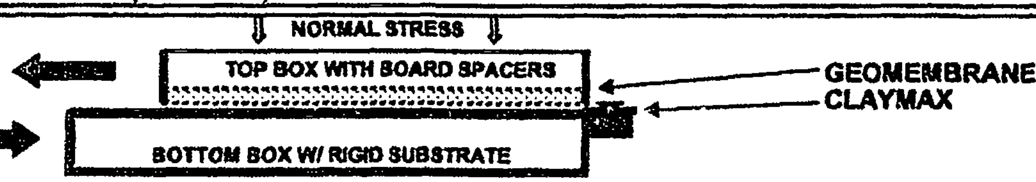
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of claymax was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of geomembrane was cut to 12" x 12" and clamped to the upper shear box.
3. Each test point was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the claymax and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

Report Date: September 25, 2006

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B Project No: 061204.02

Superstrate:	⇦	Drainage Layer		
Material 1:	⇦	GSE 60 mil HDPE Smooth, Roll# 108117338	LSN: AIP	Clamped
Material 2:	⇨	GSE Single textile Geocomposite, Roll# 131219846	LSN: AIS	Clamped
Substrate:	⇨	Concrete Board		

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	1010	14
2.	55.6	8000	2150	15
3.	111.1	16000	4360	15

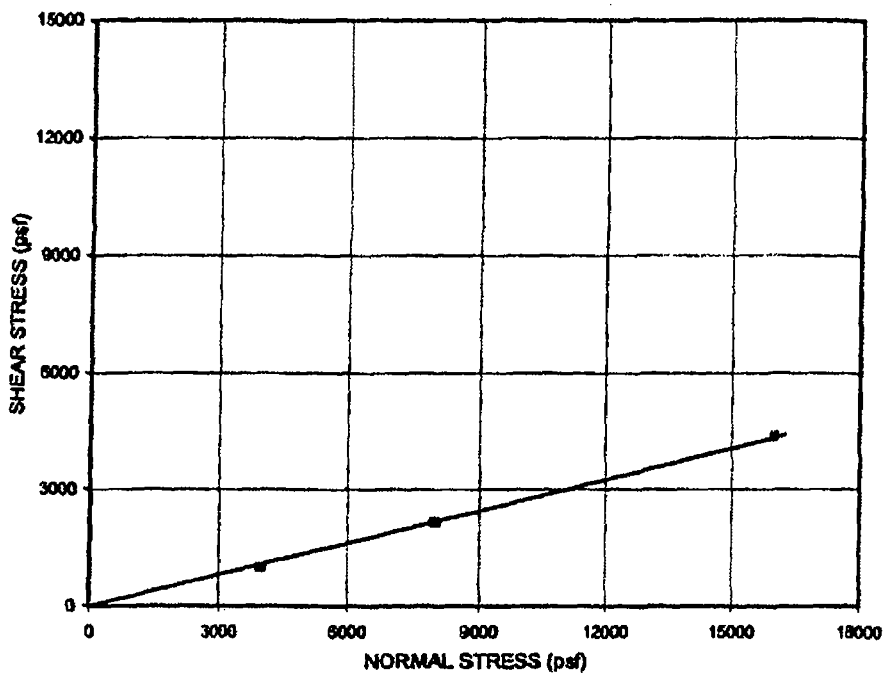
Adhesion: 0 psf

Friction Angle: 15 degrees

Coefficient of Friction: 0.27

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE
(at 3.0 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	630	9
2.	55.6	8000	1300	9
3.	111.1	16000	2860	10

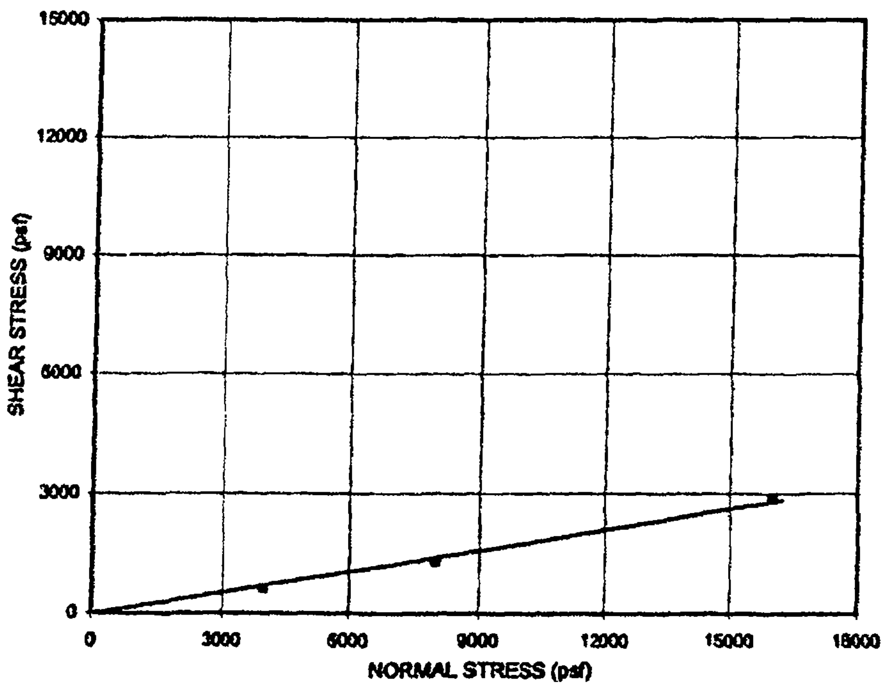
Adhesion: 0 psf

Friction Angle: 10 degrees

Coefficient of Friction: 0.17

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



L:Labexcel \ Projects \ 2006 \ 061204 \ 1979C-LSDS-rp Entered By: LM Print Date: 10/13/06 Rev. By: Lab Log:

DCN: LSDS-rp (rev., 03/01/04) **1979C**

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

Report Date: September 25, 2006

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B Project No: 061204.02

Superstrate: ⟸ Drainage Layer

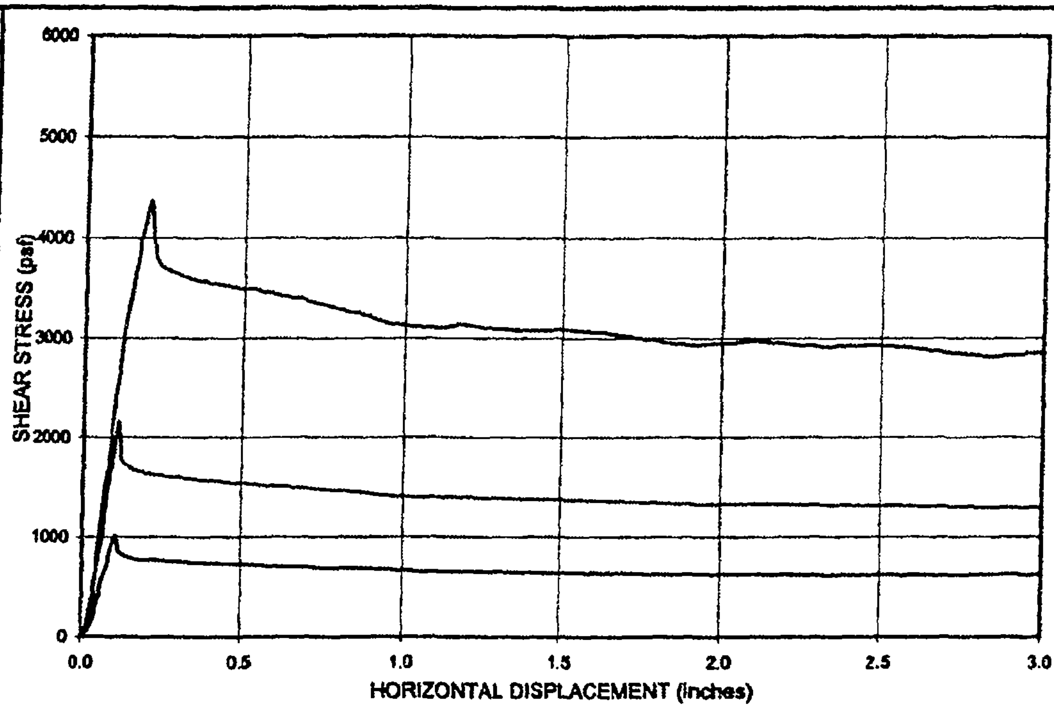
Material 1: ⟸ GSE 60 mil HDPE Smooth, Roll# 108117338 LSN: AIP Clamped

Material 2: ⟹ GSE Single textile Geocomposite, Roll# 131219846 LSN: AIS Clamped

Substrate: ⟹ Concrete Board

DISPLACEMENT vs. SHEAR STRESS

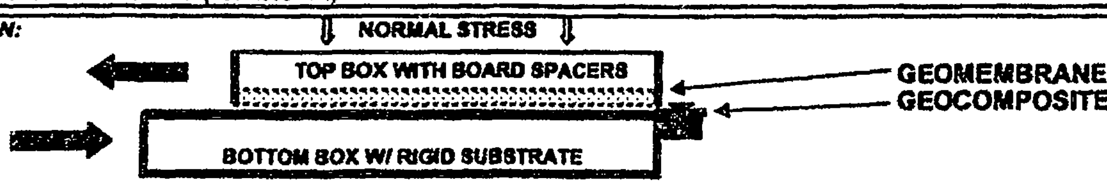
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-5321 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of geocomposite was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of geomembrane was cut to 12" x 12" and clamped to the upper shear box.
3. Each test specimen was consolidated for 1 hour at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the geocomposite and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-A

Report Date: October 6, 2006

Client Name: ALLIED WASTE INC.   Project Name: WASATCH PHASE 1B   Project No: 061204.02

Superstrate: ⇐ Rigid Board

Material 1: ⇐ Claymax   LSN: AJC   Grip Board

Material 2: ⇒ Claymax   LSN: AJC   Grip Board

Substrate: ⇒ Rigid Board

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	1470	20
2.	55.6	8000	2510	17
3.	111.1	16000	4500	16

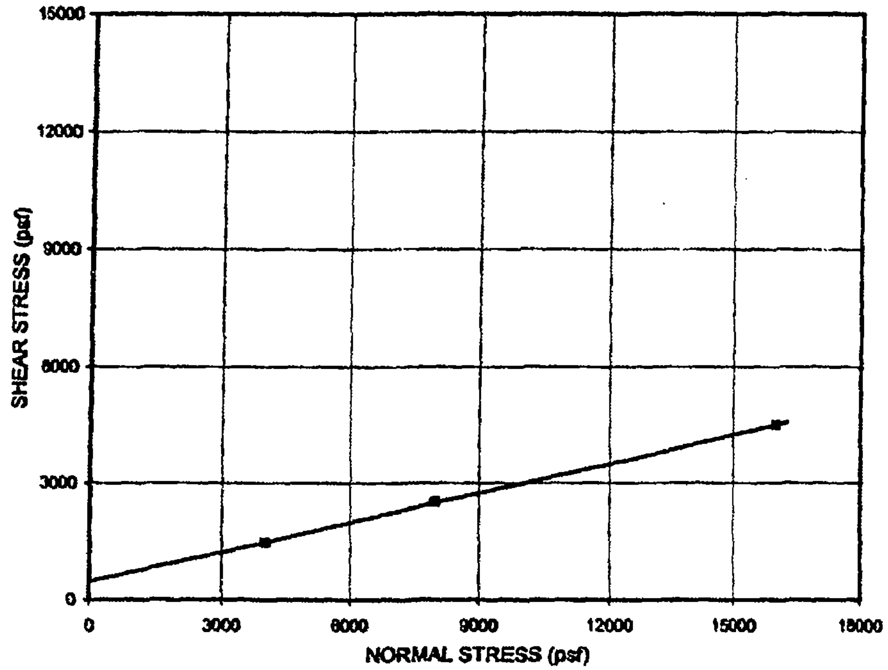
Adhesion: 470 psf

Friction Angle: 14 degrees

Coefficient of Friction: 0.25

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 3.0 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	650	9
2.	55.6	8000	1010	7
3.	111.1	16000	1630	6

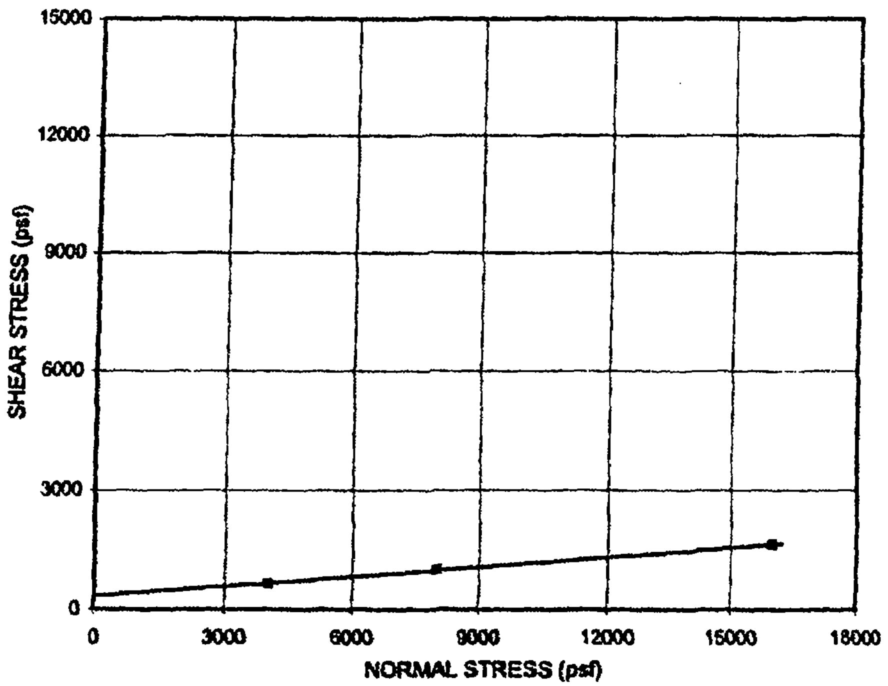
Adhesion: 340 psf

Friction Angle: 5 degrees

Coefficient of Friction: 0.08

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Report Date: October 6, 2006

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 1B Project No: 061204.02

Superstrate:	⇦ Rigid Board			
Material 1:	⇦ Claymax	LSN:	AJC	Grip Board
Material 2:	⇨ Claymax	LSN:	AJC	Grip Board
Substrate:	⇨ Rigid Board			

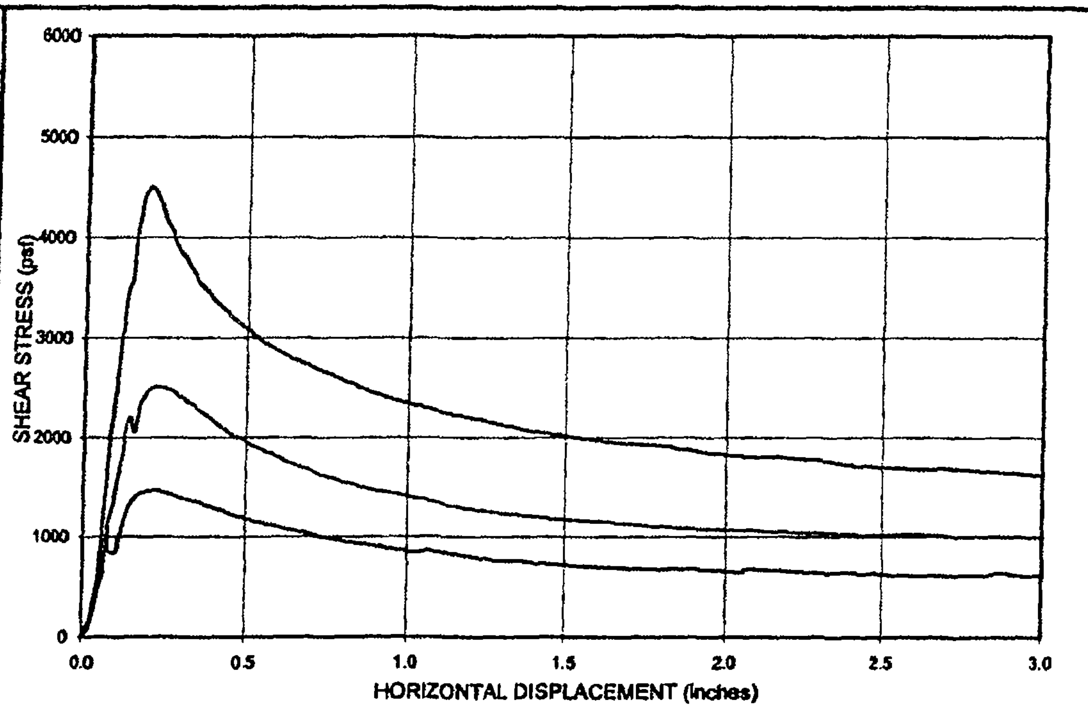
DISPLACEMENT vs. SHEAR STRESS

Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000

MOISTURE DATA:

(GCL)

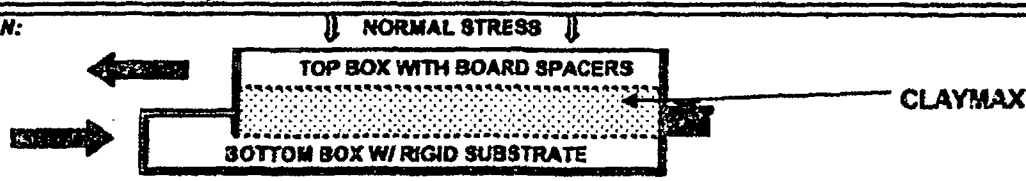
Final Water Content:(%)
1) 83.1 2) 69 3) 52.7



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x 300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of claymax was cut to 12" x 12" and gripped using grip boards.
2. Each test point was consolidated for 24 hours at the specified normal stress, then sheared.
3. The test was performed in a "wet" or "flooded" condition.
4. Shearing occurred internally.
5. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
6. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Special Shear - geosynthetic/geosynthetic

Report Date: April 29, 2008

Client Name: ALLIED WASTE INC Project Name: WASATCH REGIONAL LANDFILL PHASE 2B Project No: 061204.09

Superstrate: ⇐ Grip Board

Material 1: ⇐ CETCO GCL Bentomat ST Lot#2008 14LO Roll#1235 LSN: AOV Gripped

Material 2: ⇒ PolyFlex 60 mil HDPE T/T,Less Aggressive Side to GCL, Roll# HT1-6-07-148t LSN: AON Clamped

Substrate: ⇒ Concrete Board

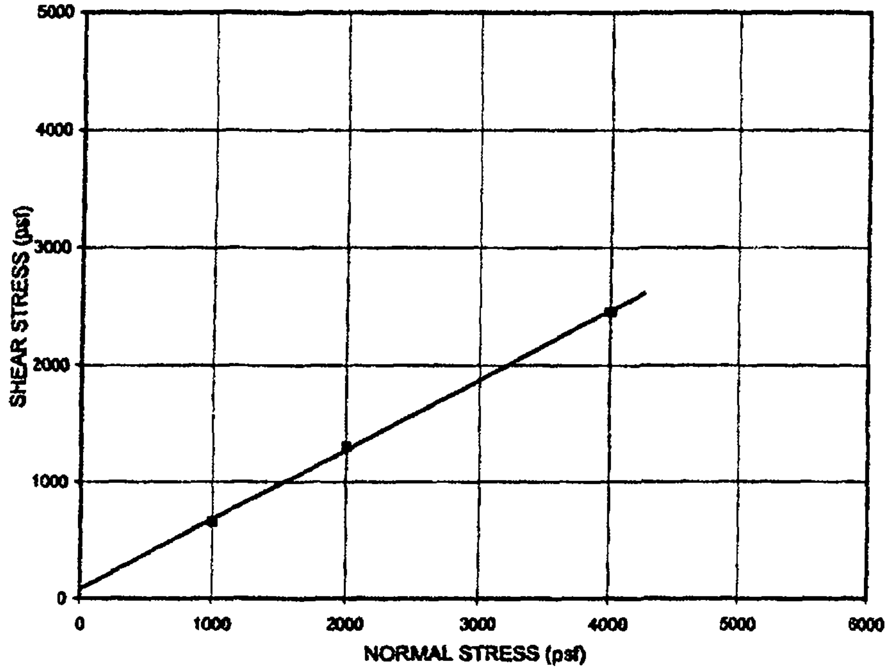
PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	6.9	1000	660	33
2.	13.9	2000	1300	33
3.	27.8	4000	2450	31

Adhesion: 80 psf

Friction Angle: 31 degrees

Coefficient of Friction: 0.6



NOTE: GRAPH NOT TO SCALE

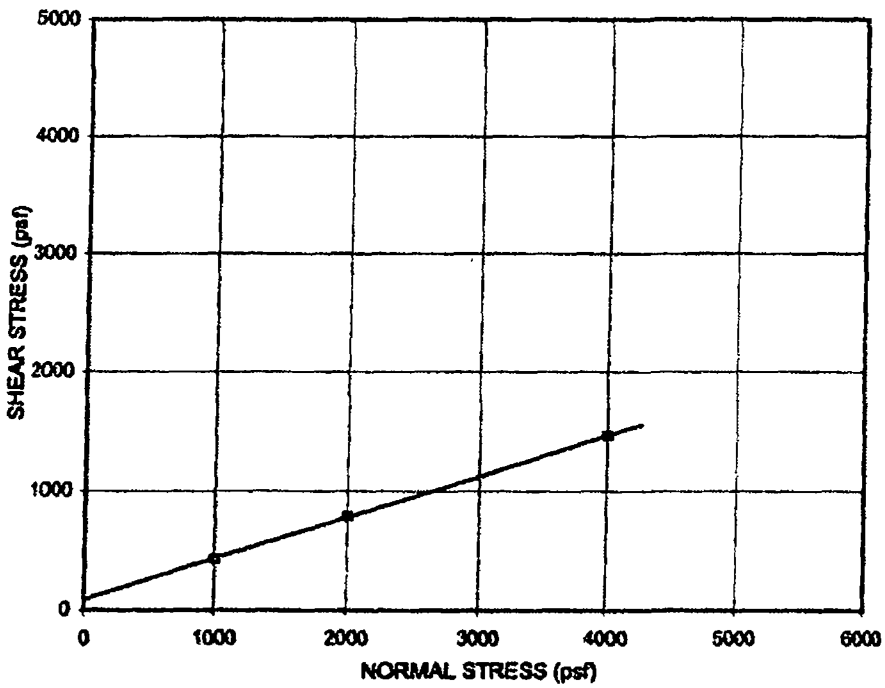
STRENGTH ENVELOPE
(at 2.5 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	6.9	1000	430	23
2.	13.9	2000	780	21
3.	27.8	4000	1460	20

Adhesion: 90 psf

Friction Angle: 19 degrees

Coefficient of Friction: 0.34



NOTE: GRAPH NOT TO SCALE

Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Special Shear - geosynthetic/geosynthetic

Report Date: April 29, 2008

Client Name: ALLIED WASTE INC — Project Name: WASATCH REGIONAL LANDFILL PHASE 2B — Project No: 061204.09

Superstrate: ⇐ Grip Board

Material 1: ⇐ CETCO GCL Bentomat ST Lot#2008 14LO Roll#1235 — LSN: AOV — Gripped

Material 2: ⇒ PolyFlex 60 mil HDPE T/T,Less Aggressive Side to GCL, Roll# HT1-6-07-148 — LSN: AON — Clamped

Substrate: ⇒ Concrete Board

DISPLACEMENT vs. SHEAR STRESS

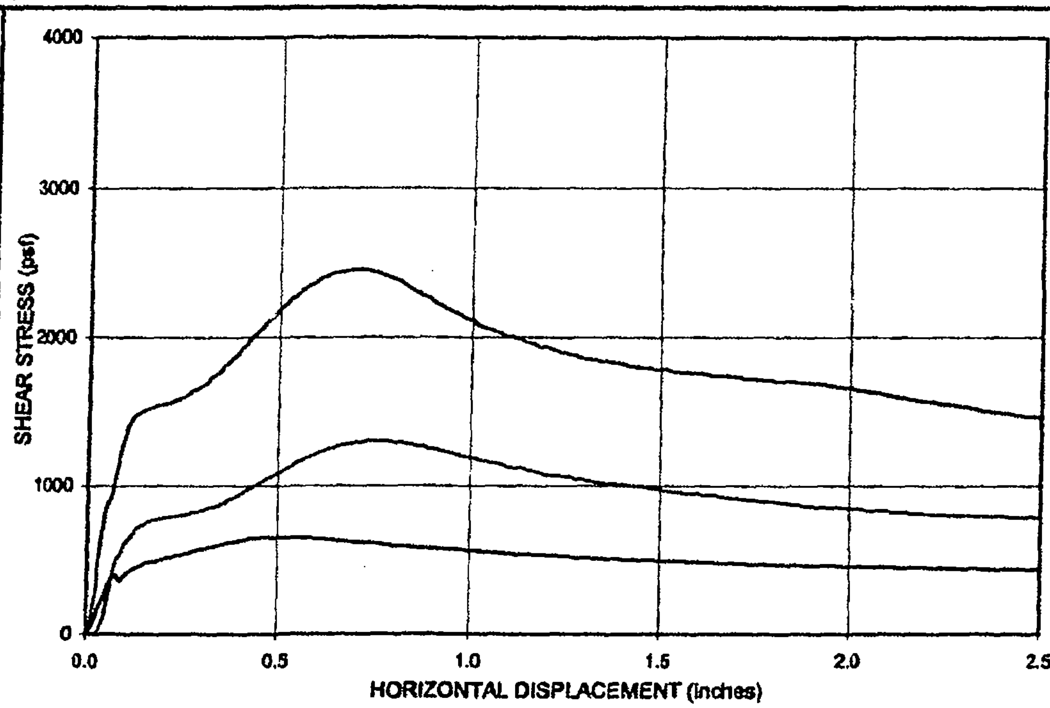
Test Point	Normal Stress psi	Normal Stress psf
1.	6.9	1000
2.	13.9	2000
3.	27.8	4000

MOISTURE DATA:

(GCL)

Initial Water Content: 20%

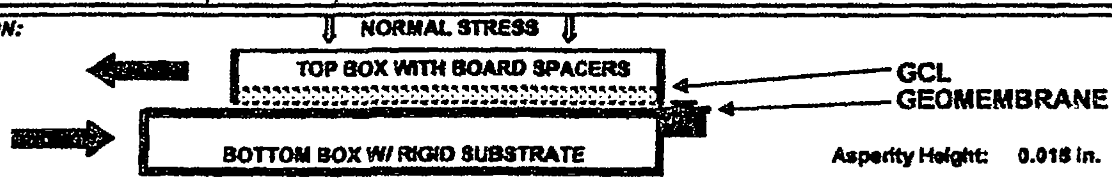
Final Water Content:(%) 1) 67.1 2) 60.5 3) 48.7



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



Asperity Height: 0.018 in.

SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each GCL specimen was cut to 12" x 12", gripped and placed into the upper shear box.
3. Each test specimen was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred mainly at the interface of the GCL and geomembrane specimens.
6. Point 1 had .75 inches (white side bunched up) of internal shearing, point 3 sheared internally (2.5 inches white side bunched up).
7. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
8. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Report Date: April 29, 2008

Client Name: ALLIED WASTE INC   Project Name: WASATCH REGIONAL LANDFILL PHASE 2B   Project No: 061204.09

Superstrate: ⟸ Grip Board

Material 1: ⟸ CETCO GCL Claymax 200R, Lot#2008 15LO, Roll#1640   LSN: AOW   Gripped

Material 2: ⟹ PolyFlex 60 mil HDPE Smooth, Roll# HS2-6-08-0029-5   LSN: AOL   Clamped

Substrate: ⟹ Concrete Board

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	930	13
2.	55.6	8000	1980	14
3.	111.1	16000	4110	14

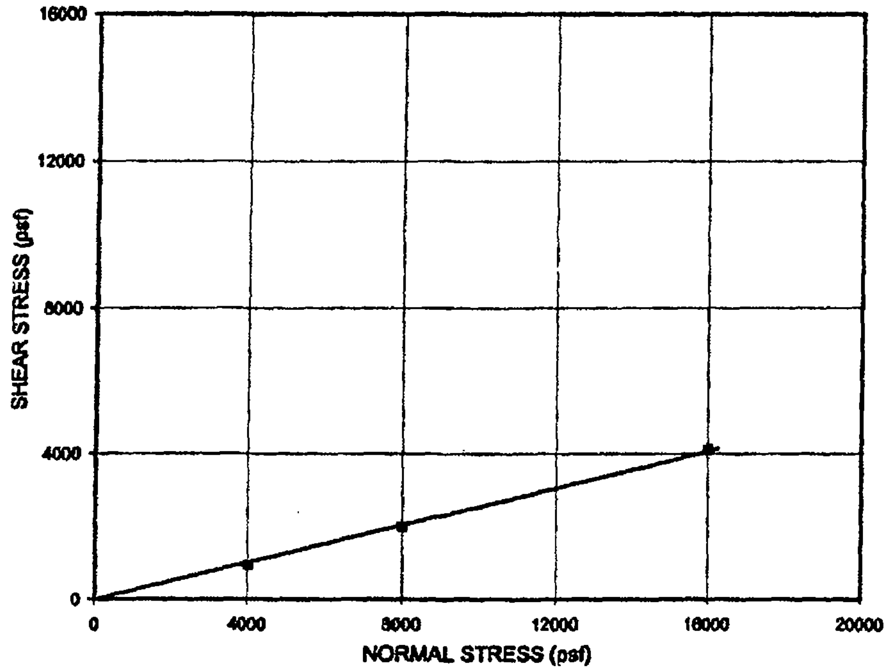
Adhesion: 0 psf

Friction Angle: 14 degrees

Coefficient of Friction: 0.25

Note: Intercept set to "0".

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 2.5 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	610	9
2.	55.6	8000	1270	9
3.	111.1	16000	2580	9

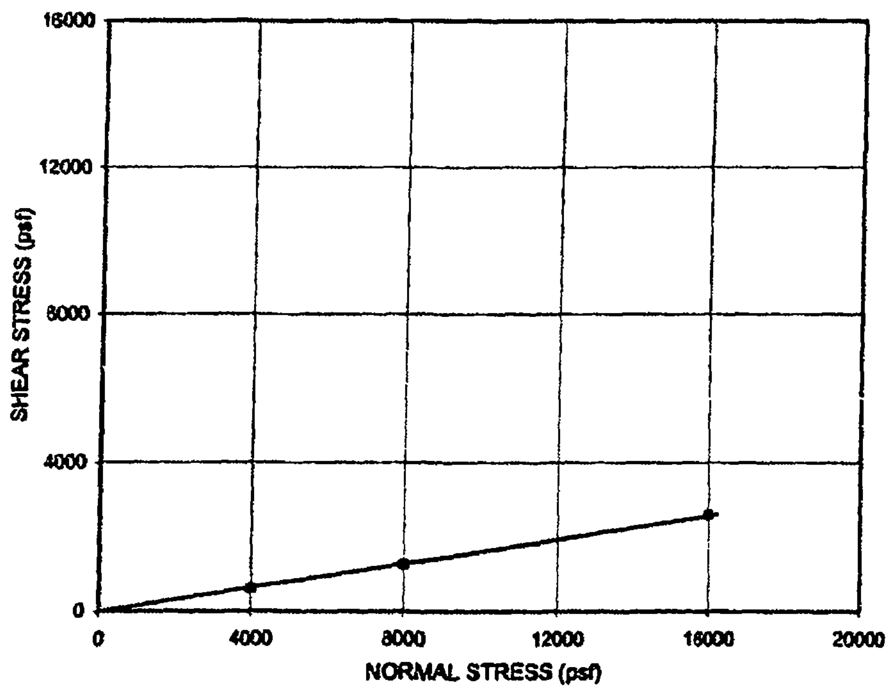
Adhesion: 0 psf

Friction Angle: 9 degrees

Coefficient of Friction: 0.16

Note: Intercept set to "0".

NOTE: GRAPH NOT TO SCALE



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DCN: LSDS-rp (rev., 03/01/04)

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Report Date: April 29, 2008

Client Name: ALLIED WASTE INC   Project Name: WASATCH REGIONAL LANDFILL PHASE 2B   Project No: 061204.09

Superstrate: ⟸ Grip Board

Material 1: ⟸ CETCO GCL Claymax 200R, Lot#2008 15LO, Roll#1640   LSN: AOW   Gripped

Material 2: ⟹ PolyFlex 60 mil HDPE Smooth, Roll# HS2-6-08-0029-5   LSN: AOL   Clamped

Substrate: ⟹ Concrete Board

DISPLACEMENT vs. SHEAR STRESS

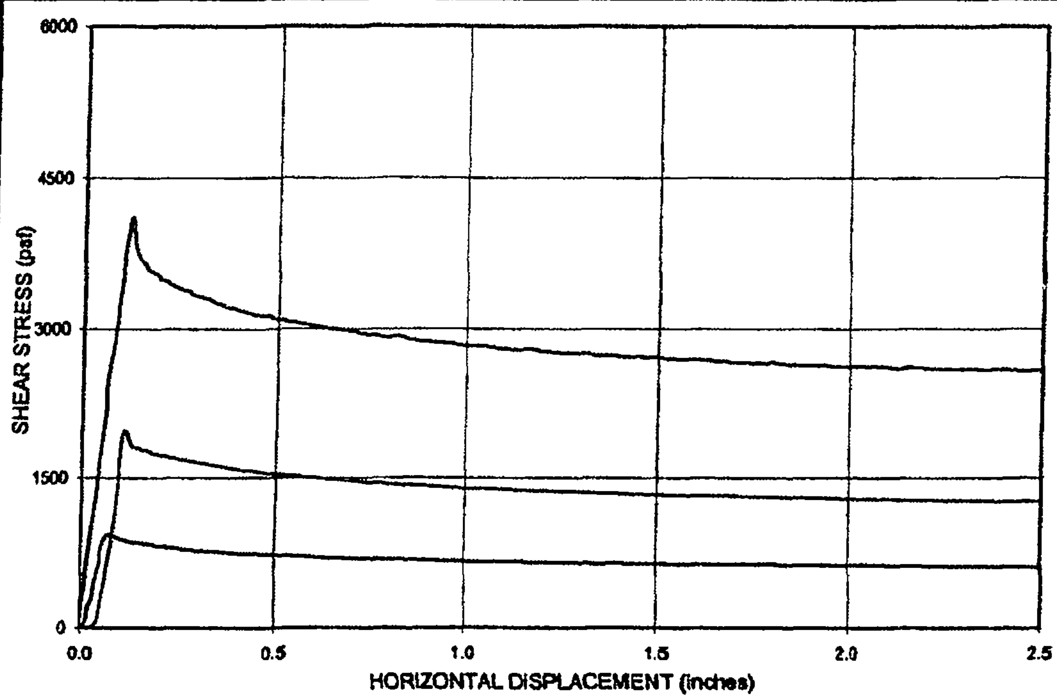
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000

MOISTURE DATA:

(GCL)

Initial Water Content: 44.77%

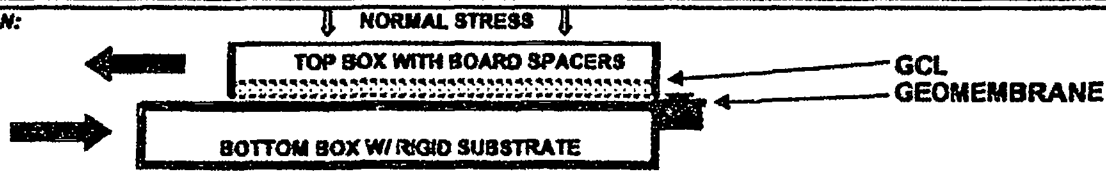
Final Water Content:(%)
1) 56.3 2) 47.6 3) 39.2



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each GCL specimen was cut to 12" x 12", gripped and placed into the upper shear box.
3. Each test specimen was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred mainly at the interface of the GCL and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

Report Date: April 29, 2008

Client Name: ALLIED WASTE INC   Project Name: WASATCH REGIONAL LANDFILL PHASE 2B   Project No: 061204.09

Superstrate: ⇦ Board Spacers

Material 1: ⇦ PolyFlex 60 mil HDPE Smooth, Roll# HS2-6-08-0029-5   LSN: AOL   Clamped

Material 2: ⇨ SKAPS Single Sided Geocomposite, Roll# TN 220-1-8 (net to HDPE)   LSN: AOP   Clamped

Substrate: ⇨ Concrete Board

PEAK STRENGTH

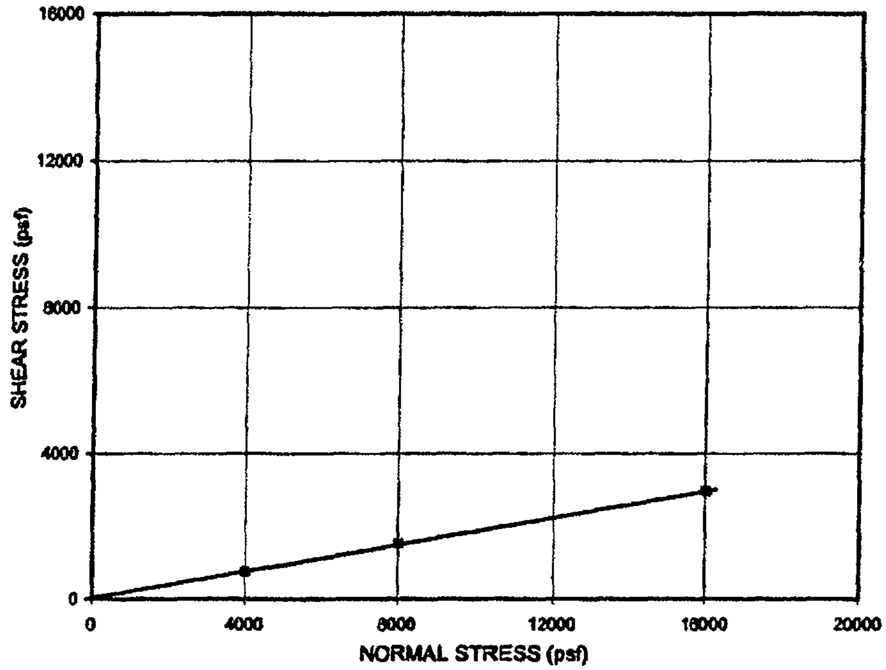
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	750	11
2.	55.6	8000	1520	11
3.	111.1	16000	2940	10

Adhesion: 40 psf

Friction Angle: 10 degrees

Coefficient of Friction: 0.18

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 2.5 in. displacement)

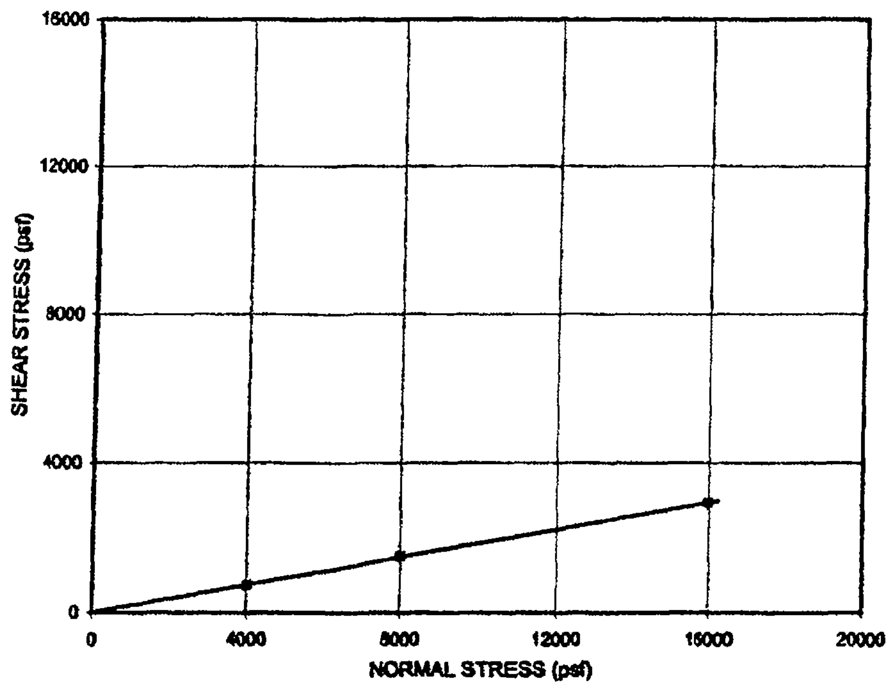
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	730	10
2.	55.6	8000	1510	11
3.	111.1	16000	2940	10

Adhesion: 20 psf

Friction Angle: 10 degrees

Coefficient of Friction: 0.18

NOTE: GRAPH NOT TO SCALE



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DCN: LSDS-rp (rev., 03/01/04)   **2495C**

Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

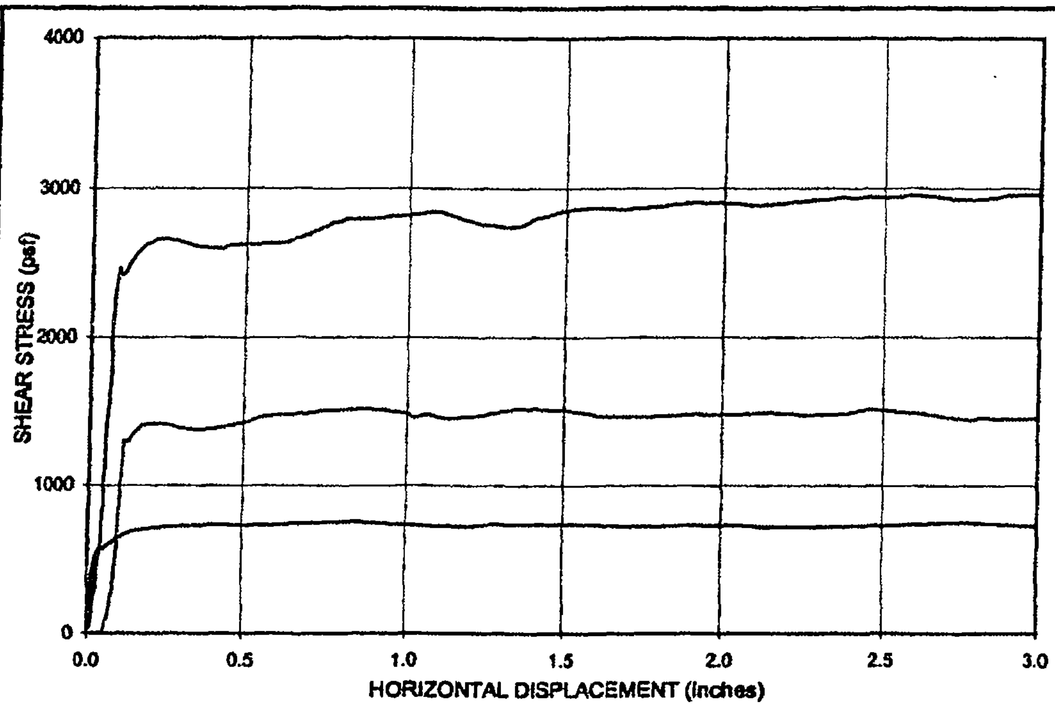
Report Date: April 29, 2008

Client Name: ALLIED WASTE INC Project Name: WASATCH REGIONAL LANDFILL PHASE 2B Project No: 061204.09

Superstrate:	Board Spacers		
Material 1:	PolyFlex 60 mil HDPE Smooth, Roll# HS2-6-08-0029-5	LSN: AOL	Clamped
Material 2:	SKAPS Single Sided Geocomposite, Roll# TN 220-1-8 (net to HDPE)	LSN: AOP	Clamped
Substrate:	Concrete Board		

DISPLACEMENT vs. SHEAR STRESS

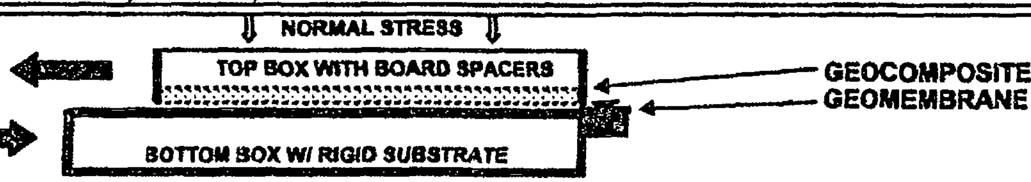
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-5321 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of geocomposite was cut to 14" x 16" and clamped to the upper shear box.
3. Each test specimen was consolidated for 1 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the geomembrane and geocomposite specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Report Date: April 9, 2007

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 2A Project No: 061204.05

Superstrate: ⇐ Grip Board & Drainage Layer

Material 1: ⇐ GSE GCL Bentofix NS, Roll# 39932, Nonwoven side towards HDPE LSN: AKS Grip Board

Material 2: ⇒ GSE 60 mil HDPE Double textured, Roll# 103138468 LSN: ALH Clamped

Substrate: ⇒ Concrete Board

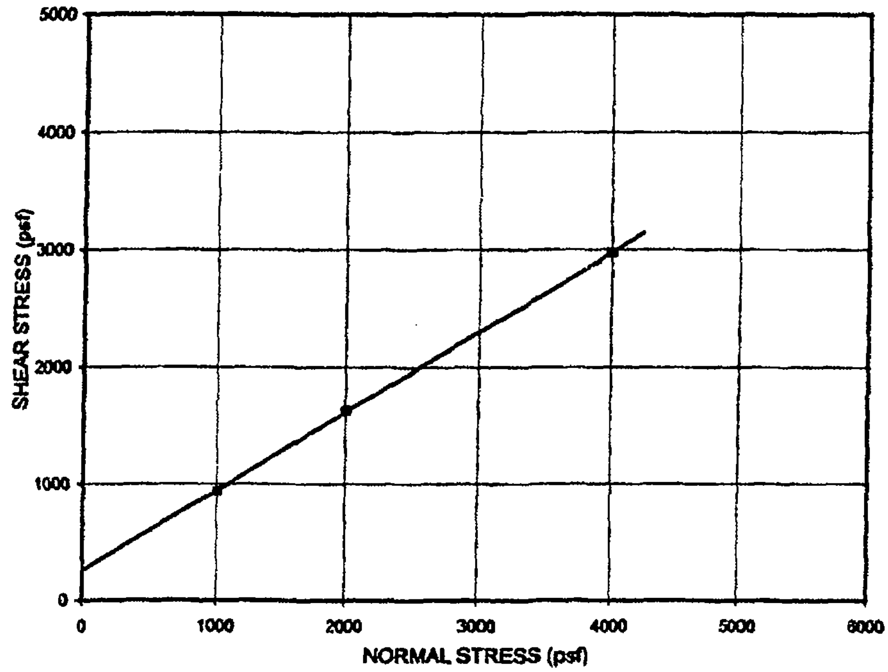
PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	6.9	1000	930	43
2.	13.9	2000	1620	39
3.	27.8	4000	2970	37

Adhesion: 260 psf

Friction Angle: 34 degrees

Coefficient of Friction: 0.68



NOTE: GRAPH NOT TO SCALE

STRENGTH ENVELOPE

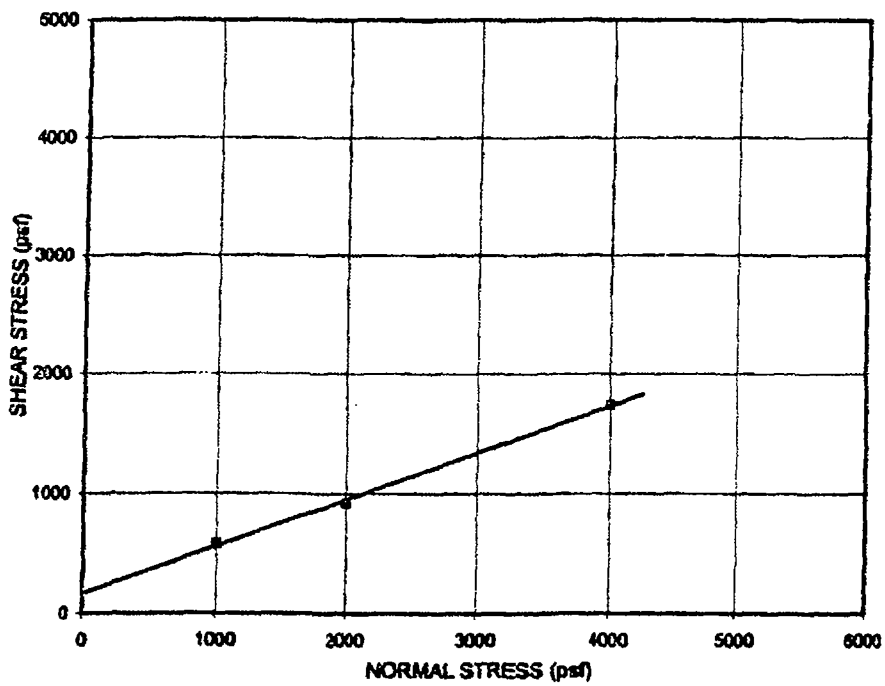
(at 2.5 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	6.9	1000	580	30
2.	13.9	2000	920	25
3.	27.8	4000	1740	24

Adhesion: 160 psf

Friction Angle: 21 degrees

Coefficient of Friction: 0.39



NOTE: GRAPH NOT TO SCALE

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DCN: LSDS-rp (rev., 03/01/04) **2133A**

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Client Name: ALLIED WASTE INC.	Project Name: WASATCH PHASE 2A			Report Date:	April 9, 2007
				Project No:	061204.05
Superstrate:	⟸ Grip Board & Drainage Layer				
Material 1:	⟸ GSE GCL Bentofix NS, Roll# 39932, Nonwoven side towards HDPE	LSN:	AKS	Grip Board	
Material 2:	⟹ GSE 60 mil HDPE Double textured, Roll# 103138468	LSN:	ALH	Clamped	
Substrate:	⟹ Concrete Board				

DISPLACEMENT vs. SHEAR STRESS

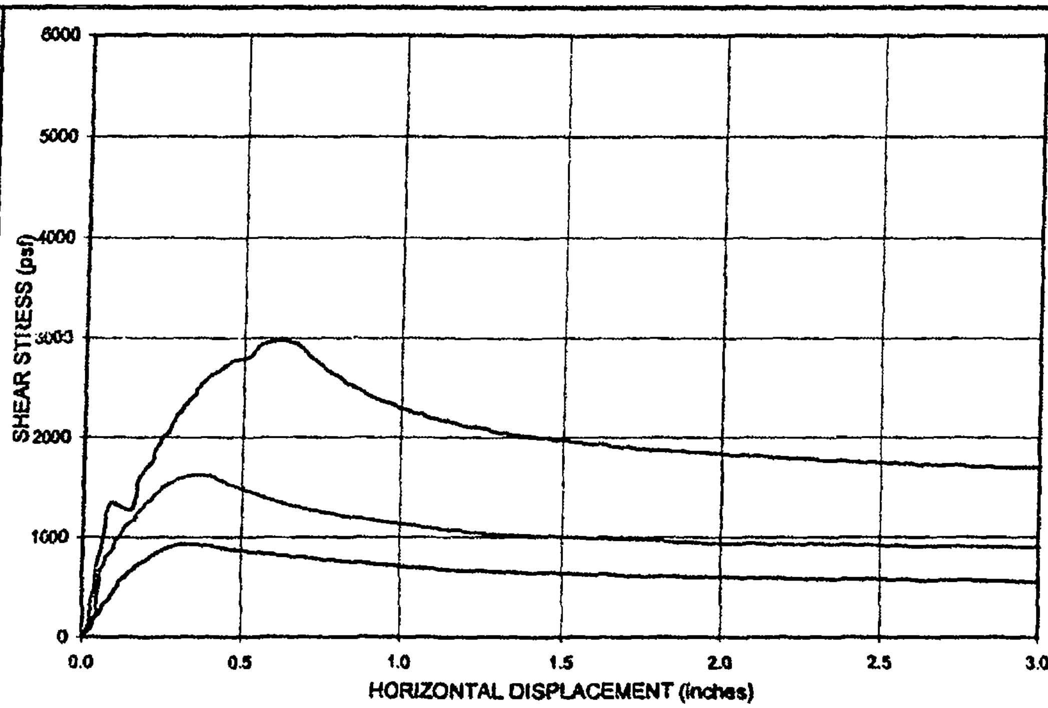
Test Point	Normal Stress psi	Normal Stress psf
1.	6.9	1000
2.	13.9	2000
3.	27.8	4000

MOISTURE DATA:

(GCL)

Initial Water Content: 7.5%

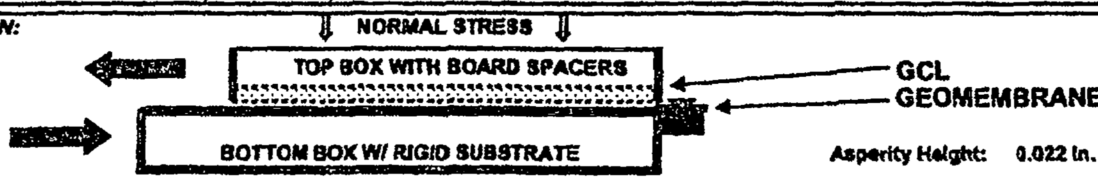
Final Water Content:(%)
1) 62.2 2) 60.4 3) 59.8



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



Asperity Height: 0.022 in.

SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of GCL was cut to 12" x 12", then placed on the geomembrane and gripped using a grip board.
3. Each test point was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the GCL and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Report Date: April 10, 2007

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 2A Project No: 061204.05

Superstrate: ⇦ Grip Board & Drainage Layer

Material 1: ⇦ GSE GCL Bentofix EC, Roll# 502100520, Nonwoven side towards HDPE LSN: ALI Grip Board

Material 2: ⇨ GSE 60 mil HDPE Smooth, Roll# 108120131 LSN: ALD Clamped

Substrate: ⇨ Concrete Board

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	1180	16
2.	55.6	8000	2290	16
3.	111.1	16000	4890	17

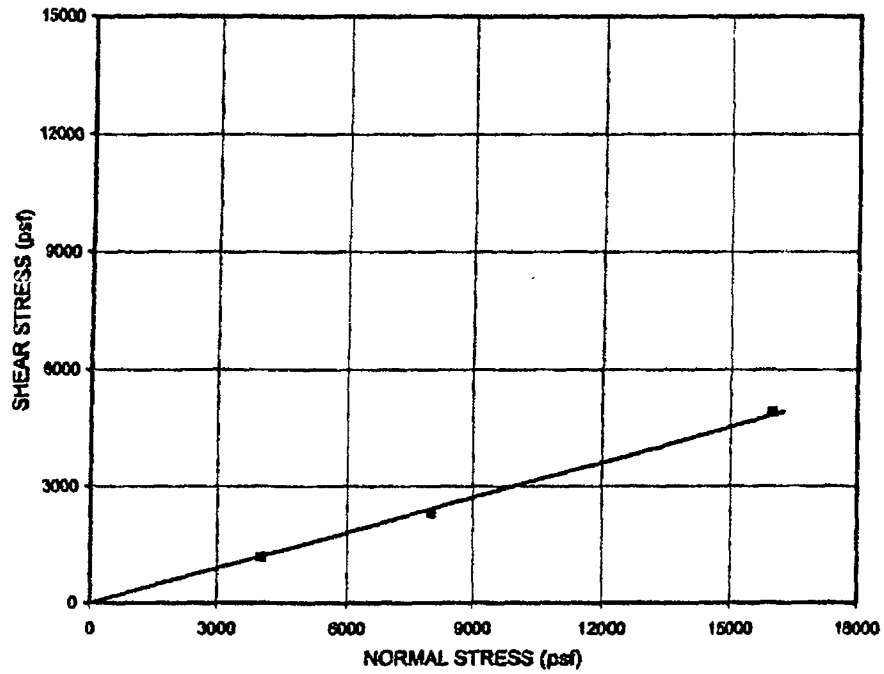
Adhesion: 0 psf

Friction Angle: 17 degrees

Coefficient of Friction: 0.3

Note: Intercept adjusted to 0.

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 2.5 in. displacement)

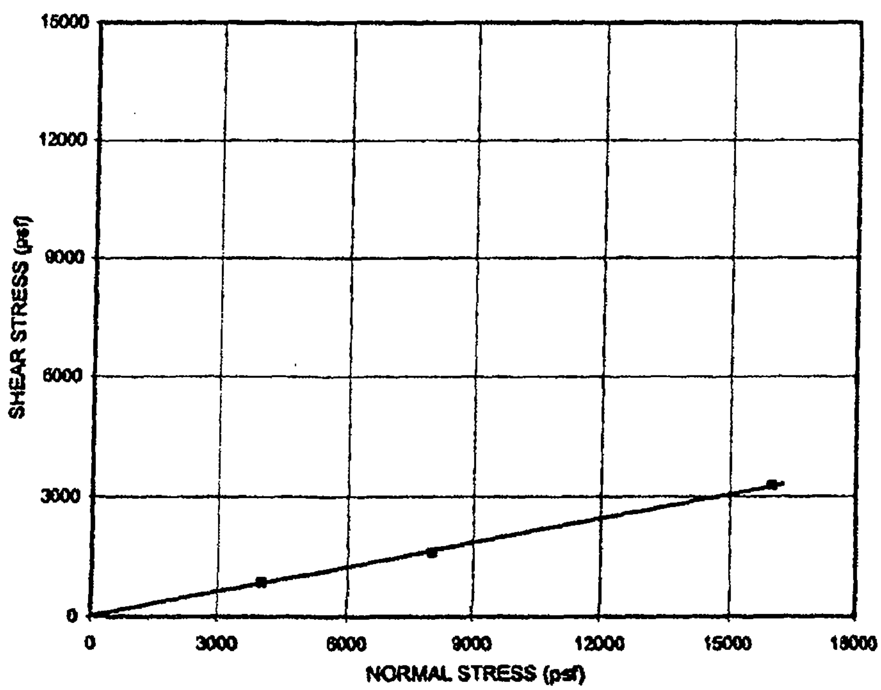
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	870	12
2.	55.6	8000	1600	11
3.	111.1	16000	3280	12

Adhesion: 30 psf

Friction Angle: 11 degrees

Coefficient of Friction: 0.2

NOTE: GRAPH NOT TO SCALE



Vector Engineering Inc.

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LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-6243-B

Client Name: ALLIED WASTE INC.	Project Name: WASATCH PHASE 2A	Report Date:	April 10, 2007
		Project No:	061204.05

Superstrate: ⇐ Grip Board & Drainage Layer			
Material 1: ⇐ GSE GCL Bentofix EC, Roll# 502100520, Nonwoven side towards HDPE	LSN: ALI		Grip Board
Material 2: ⇒ GSE 60 mil HDPE Smooth, Roll# 108120131	LSN: ALD		Clamped
Substrate: ⇒ Concrete Board			

DISPLACEMENT vs. SHEAR STRESS

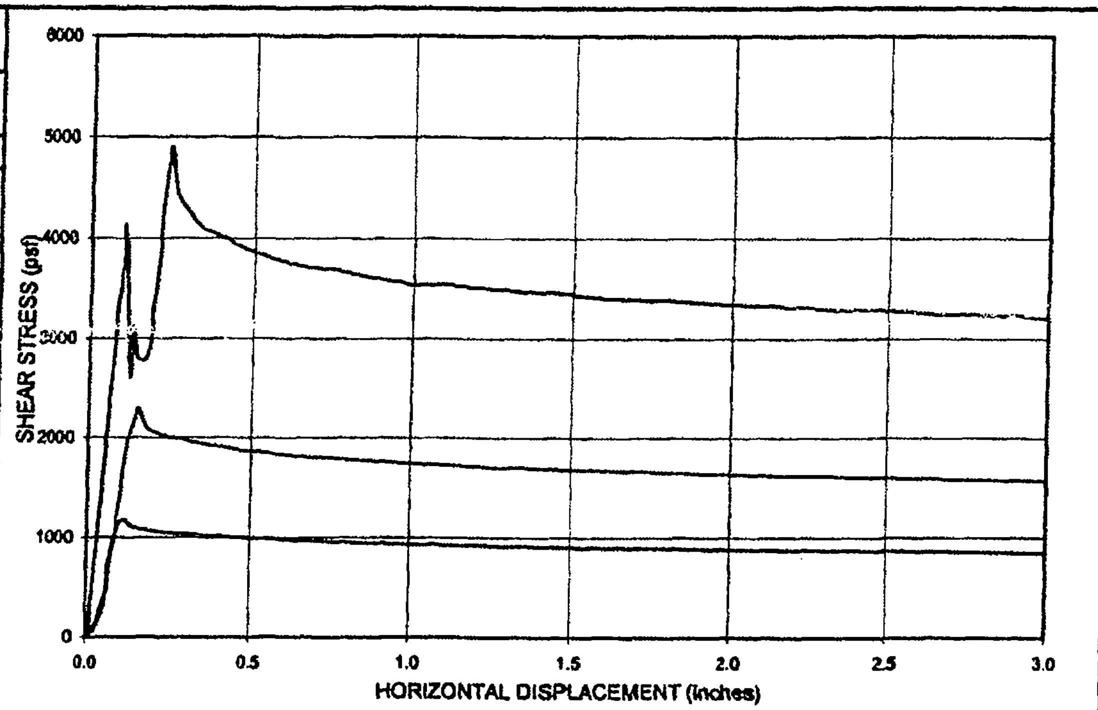
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000

MOISTURE DATA:

(GCL)

Initial Water Content: 9.8%

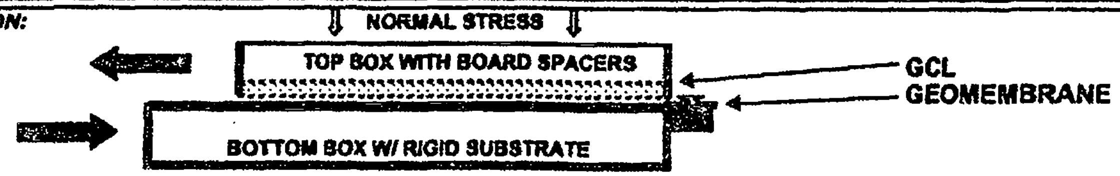
Final Water Content:(%)
1) 63.3 2) 60.6 3) 54.7



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-6243 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of geomembrane was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of GCL was cut to 12" x 12", then placed on the geomembrane and gripped using a grip board.
3. Each test point was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the GCL and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

Report Date: April 6, 2007

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 2A Project No: 061204.05

Superstrate: ⇐ Drainage Layer

Material 1: ⇐ GSE 60 mil HDPE Smooth, Roll# 108120131 LSN: ALD Clamped

Material 2: ⇒ GSE Single side textile Geocomposite, Roll# 131238484 LSN: ALG Clamped

Substrate: ⇒ Concrete Board

PEAK STRENGTH

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	950	13
2.	55.6	8000	1860	13
3.	111.1	16000	4380	15

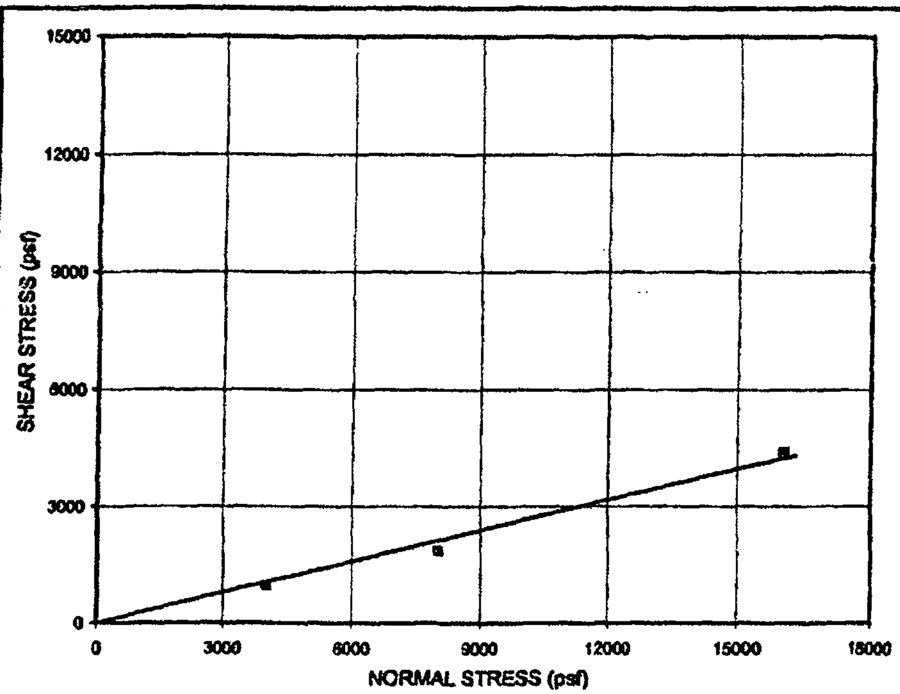
Adhesion: 0 psf

Friction Angle: 15 degrees

Coefficient of Friction: 0.26

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE
(at 2.5 in. displacement)

Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	27.8	4000	610	9
2.	55.6	8000	1300	9
3.	111.1	16000	2960	10

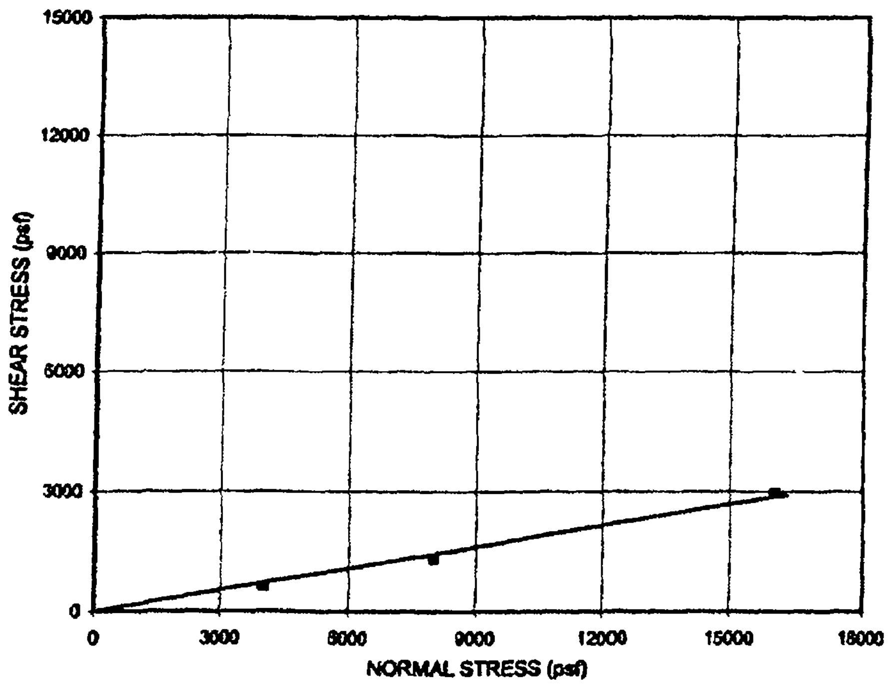
Adhesion: 0 psf

Friction Angle: 10 degrees

Coefficient of Friction: 0.18

Note: Intercept Adjusted to "0".

NOTE: GRAPH NOT TO SCALE



Labexcel \ Projects \ 2006 \ 061204 \ 2133C-LSDS-rp Entered By: LM Print Date: 07/06/07 Rev. By: Lab Log:

DCN: LSDS-rp (rev., 03/01/04) **2133C**

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321A

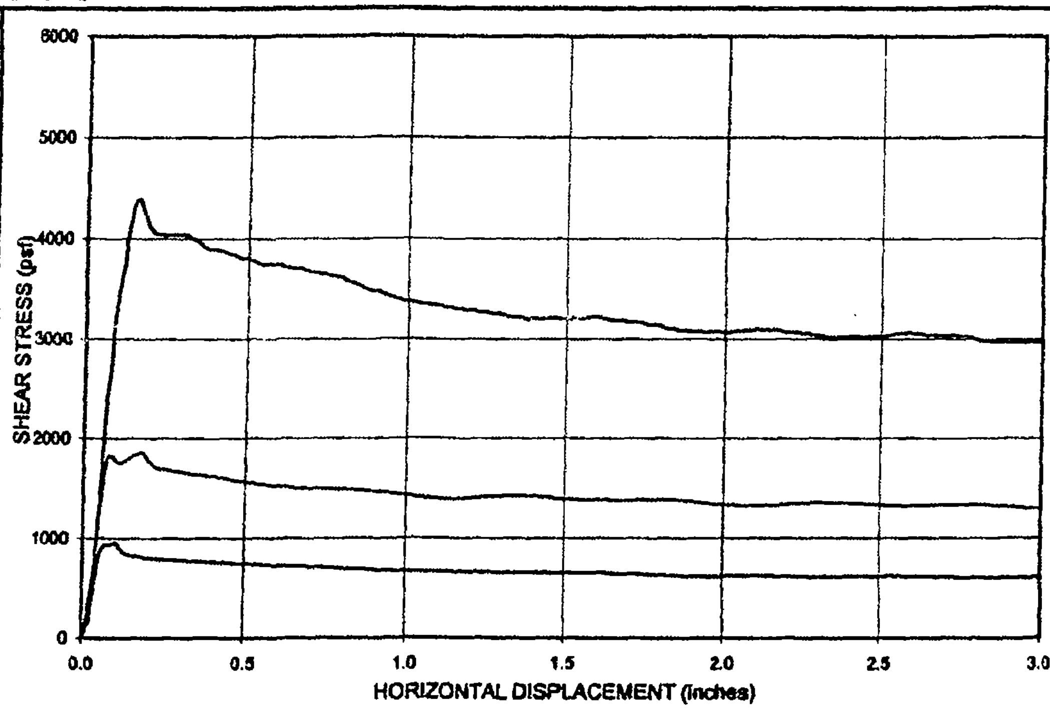
Report Date: April 6, 2007

Client Name: ALLIED WASTE INC. Project Name: WASATCH PHASE 2A Project No: 061204.05

Superstrate:	⇐ Drainage Layer			
Material 1:	⇐ GSE 60 mil HDPE Smooth, Roll# 108120131	LSN:	ALD	Clamped
Material 2:	⇒ GSE Single side textile Geocomposite, Roll# 131238484	LSN:	ALG	Clamped
Substrate:	⇒ Concrete Board			

DISPLACEMENT vs. SHEAR STRESS

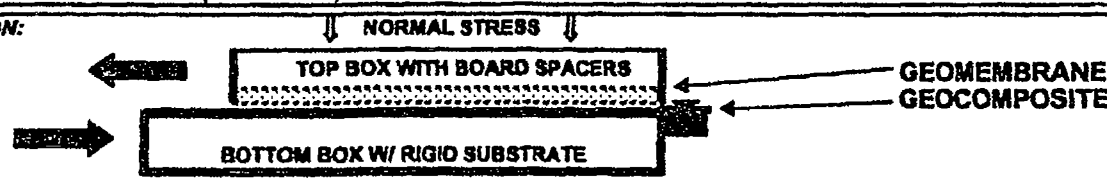
Test Point	Normal Stress psi	Normal Stress psf
1.	27.8	4000
2.	55.6	8000
3.	111.1	16000



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-5321 using a Brainard-Kilman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. Each specimen of geocomposite was cut to 14" x 20" and clamped to the lower shear box.
2. Each specimen of geomembrane was cut to 12" x 12" and clamped to the upper shear box.
3. Each test specimen was consolidated for 1 hour at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred at the interface of the geocomposite and geomembrane specimens.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

	Friction Angle and Cohesion											
	HDPE Textured / GCL		HDPE Smooth / GCL		HDPE Textured / Single Sided Geocomposite HDPE Textured / Geonet		HDPE Textured / Double Sided Geocomposite HDPE Textured / Geotextile		HDPE Smooth / Single Sided Geocomposite HDPE Smooth / Geonet		HDPE Smooth / Double Sided Geocomposite HDPE Smooth / Geotextile	
	Friction Angle	Cohesion	Friction Angle	Cohesion	Friction Angle	Cohesion	Friction Angle	Cohesion	Friction Angle	Cohesion	Friction Angle	Cohesion
	13	0	29	20	11	60	21	90	13	0	12	20
	10	290	13	390	19	50	16	80	11	0	9	0
	8	460	12	360	9	40	15	90	14	0	10	20
	7	460	6	300	15	20	12	230	10	70	10	20
	8	410	10	70	14	0	16	110	10	30	9	30
	9	280	11	0	16	160	21	90			8	50
	5	480	11	270	23	20	16	80			10	20
	16	90	5	50	16	0	26	10			9	20
	2	570	5	310	19	49	17	40			9	20
	16	120			12	0	21	50			9	20
	11	70			15	0	14	160			10	0
	11	290			15	24	13	490			10	0
	29	0			15	86	14	250			11	0
	10	70			12	410	13	470			11	0
	11	90			14	0	11	520			9	70
	12	100					11	220			6	20
	11	100					20	100			9	80
	11	110					15	130			8	40
	13	60					12	130			8	0
	14	40					14	120			9	0
	12	110					13	160				
	7	330					16	720				
	33	70					13	350				
	20	30					16	680				
	13	70					11	180				
	12	310					14	300				
	12	350					15	250				
	13	280					17	760				
	25	110					13	340				
	18	500					22	90				
	16	150					11	440				
	17	220					11	450				
	11	940					11	520				
	22	230					11	350				
	12	370					13	160				
	28	190					12	390				
	34	220					15	140				
	15	50					12	590				
	11	220					9	810				
							10	450				
							11	390				
							13	390				
							14	290				
							12	310				
Count	39	39	9	9	15	15	44	44	5	5	20	20
Maximum	34	940	29	390	23	410	26	810	14	70	12	80
Minimum	2	0	6	0	9	0	9	10	10	0	8	0
Average	14	226	12	197	15	60	14	295	12	20	9	22
Standad Deviation	16	491	12	195	7	221	9	405	2	36	2	41
Max - Average	20	714	17	193	8	350	12	515	2	50	3	59
Average - Min	12	226	6	197	6	60	5	285	2	20	1	22

APPENDIX B
SEISMIC HAZARD DATA

Faults Near Wasatch Regional Landfill

Project: Wasatch Regional Landfill — Jul-08

FAULT NAME	μ (dyne/cm2)	Fault Length (km)	Fault Width (km)	A (km2)	A (cm2)	D (mm/yr)	D (cm/yr)	uAD	M(char)	Mmin	b (assumed)	β	c2	Rrup	Rjb	Rx	Idriss
East Great Salt Lake fault zone, Antelope Island section	3.00E+11	35	15	525	5.25E+12	0.8	0.08	1.3E+24	6.7	5	1	2.30	0.39	45	45	0	
Stansbury fault zone	3.00E+11	50	15	750	7.5E+12	0.2	0.02	4.5E+23	6.9	5	1	2.30	0.27	14	14	0	0.436
Lakeside Mountains (west side) fault	3.00E+11	5	15	75	7.5E+11	0.2	0.02	4.5E+22	5.9	5	1	2.30	3.25	10	10	0	0.273
Skull Valley (mid-valley) faults	3.00E+11	55	15	825	8.25E+12	0.2	0.02	5.0E+23	6.9	5	1	2.30	0.25	35	35	0	0.182
Puddle Valley fault zone	3.00E+11	7	15	105	1.05E+12	0.2	0.02	6.3E+22	6.1	5	1	2.30	2.16	24	24	0	0.136
Oquirrh fault zone	3.00E+11	21	50	1050	1.05E+13	0.8	0.08	2.5E+24	7.0	5	1	2.30	0.19	47	47	0	0.135
East Great Salt Lake fault zone, Promontory section	3.00E+11	37	15	555	5.55E+12	0.8	0.08	1.3E+24	6.8	5	1	2.30	0.37	48	48	0	0.121
East Great Salt Lake fault zone, Antelope Island section	3.00E+11	26	15	390	3.9E+12	0.8	0.08	9.4E+23	6.6	5	1	2.30	0.53	40	40	0	0.11
Southern Oquirrh Mountains fault zone	3.00E+11	24	50	1200	1.2E+13	0.8	0.08	2.9E+24	7.1	5	1	2.30	0.17	58	58	0	0.109
East Great Salt Lake fault zone, Fremont Island section	3.00E+11	13	15	195	1.95E+12	0.8	0.08	4.7E+23	6.3	5	1	2.30	1.39	40	40	0	0.086
Wasatch fault zone, Salt Lake City section	3.00E+11	23	50	1150	1.15E+13	4	0.4	1.4E+25	7.1	5	1	2.30	0.18	72	72	0	0.083
Wasatch fault zone, Weber section	3.00E+11	20	50	1000	1E+13	4	0.4	1.2E+25	7.0	5	1	2.30	0.20	72	72	0	0.079
Wasatch fault zone, Clarkston Mountain section	3.00E+11	43	50	2150	2.15E+13	0.2	0.02	1.3E+24	7.3	5	1	2.30	0.10	80	80	0	0.079
Wasatch fault zone, Provo section	3.00E+11	23	50	1150	1.15E+13	4	0.4	1.4E+25	7.1	5	1	2.30	0.18	80	80	0	0.072
West Valley fault zone, Taylorsville fault	3.00E+11	31	15	465	4.65E+12	0.2	0.02	2.8E+23	6.7	5	1	2.30	0.44	64	64	0	0.066
West Valley fault zone, Granger section	3.00E+11	32	15	480	4.8E+12	0.8	0.08	1.2E+24	6.7	5	1	2.30	0.43	64	64	0	0.066
Antelope Range-Kingsley Mountains fault zone	3.00E+11	93	15	1395	1.395E+13	0.2	0.02	8.4E+23	7.2	5	1	2.30	0.15	105	105	0	0.052
Wasatch fault zone, Nephi section	3.00E+11	56	50	2800	2.8E+13	4	0.4	3.4E+25	7.4	5	1	2.30	0.07	113	113	0	0.052
Wasatch fault zone, Brigham City section	3.00E+11	15	50	750	7.5E+12	4	0.4	9.0E+24	6.9	5	1	2.30	0.27	97	97	0	0.05
Wasatch fault zone, Collinston section	3.00E+11	35	50	1750	1.75E+13	0.2	0.02	1.1E+24	7.2	5	1	2.30	0.12	113	113	0	0.047
Porcupine Mountain faults	3.00E+11	59	15	885	8.85E+12	0.2	0.02	5.3E+23	7.0	5	1	2.30	0.23	105	105	0	0.047
West Valley fault zone, Granger section	3.00E+11	16	15	240	2.4E+12	0.8	0.08	5.8E+23	6.4	5	1	2.30	0.87	72	72	0	0.043
Topliff Hill fault zone	3.00E+11	20	15	300	3E+12	0.2	0.02	1.8E+23	6.5	5	1	2.30	0.69	80	80	0	0.04
North Promontory fault	3.00E+11	30	15	450	4.5E+12	0.2	0.02	2.7E+23	6.7	5	1	2.30	0.45	97	97	0	0.037
Broadmouth Canyon faults	3.00E+11	35	15	525	5.25E+12	0.2	0.02	3.2E+23	6.7	5	1	2.30	0.39	97	97	0	0.037
Saint John Station fault zone	3.00E+11	5	15	75	7.5E+11	0.2	0.02	4.5E+22	5.9	5	1	2.30	3.25	60	60	0	0.036
Sheeprock fault zone	3.00E+11	12	15	180	1.8E+12	0.2	0.02	1.1E+23	6.3	5	1	2.30	1.18	80	80	0	0.034
Drum Mountains fault zone	3.00E+11	52	15	780	7.8E+12	0.2	0.02	4.7E+23	6.9	5	1	2.30	0.26	129	129	0	0.033
Clover fault zone	3.00E+11	4	15	60	6E+11	0.2	0.02	3.6E+22	5.8	5	1	2.30	4.34	61	61	0	0.032
Wasatch fault zone, Levan segment	3.00E+11	43	50	2150	2.15E+13	4	0.4	2.6E+25	7.3	5	1	2.30	0.10	153	153	0	0.031
Utah Lake faults	3.00E+11	10	15	150	1.5E+12	0.2	0.02	9.0E+22	6.2	5	1	2.30	1.45	80	80	0	0.031
West Cache fault zone, Clarkston fault	3.00E+11	49	15	735	7.35E+12	0.8	0.08	1.8E+24	6.9	5	1	2.30	0.28	137	137	0	0.03
East Cache fault zone, southern section	3.00E+11	35	15	525	5.25E+12	0.2	0.02	3.2E+23	6.7	5	1	2.30	0.39	113	113	0	0.029
Wasatch fault zone, Fayette section	3.00E+11	59	50	2950	2.95E+13	0.2	0.02	1.8E+24	7.5	5	1	2.30	0.07	177	177	0	0.028
Strawberry fault	3.00E+11	41	15	615	6.15E+12	0.2	0.02	3.7E+23	6.8	5	1	2.30	0.33	137	137	0	0.028
Antelope Range-Kingsley Mountains fault zone	3.00E+11	65	15	975	9.75E+12	0.2	0.02	5.9E+23	7.0	5	1	2.30	0.21	146	146	0	0.028
James Peak fault	3.00E+11	20	15	300	3E+12	0.2	0.02	1.8E+23	6.5	5	1	2.30	0.69	105	105	0	0.027
West Cache fault zone, Wellsville fault	3.00E+11	35	15	525	5.25E+12	0.2	0.02	3.2E+23	6.7	5	1	2.30	0.39	121	121	0	0.026
Fish Springs fault	3.00E+11	30	15	450	4.5E+12	0.2	0.02	2.7E+23	6.7	5	1	2.30	0.45	121	121	0	0.026
Gunnison fault	3.00E+11	59	15	885	8.85E+12	4	0.4	1.1E+25	7.0	5	1	2.30	0.23	158	158	0	0.025
House Range (west side) fault	3.00E+11	46	15	690	6.9E+12	0.2	0.02	4.1E+23	6.9	5	1	2.30	0.30	153	153	0	0.025
West Cache fault zone, Junction Hills fault	3.00E+11	30	15	450	4.5E+12	0.2	0.02	2.7E+23	6.7	5	1	2.30	0.45	129	129	0	0.024
Hansel Valley fault	3.00E+11	10	15	150	1.5E+12	0.2	0.02	9.0E+22	6.2	5	1	2.30	1.45	97	97	0	0.023
Schell Creek Range fault	3.00E+11	99	15	1485	1.485E+13	0.2	0.02	8.9E+23	7.2	5	1	2.30	0.14	177	177	0	0.023
Independence Valley fault zone, southern section	3.00E+11	43	15	645	6.45E+12	0.2	0.02	3.9E+23	6.8	5	1	2.30	0.32	161	161	0	0.022
Pilot Creek Valley fault	3.00E+11	27	15	405	4.05E+12	0.2	0.02	2.4E+23	6.6	5	1	2.30	0.51	127	127	0	0.022
East Dayton-Oxford fault	3.00E+11	24	15	360	3.6E+12	0.2	0.02	2.2E+23	6.6	5	1	2.30	0.57	129	129	0	0.022
Vernon Hills fault zone	3.00E+11	4	15	60	6E+11	0.2	0.02	3.6E+22	5.8	5	1	2.30	4.34	84	84	0	0.019
Porcupine Mountain faults	3.00E+11	16	15	240	2.4E+12	0.2	0.02	1.4E+23	6.4	5	1	2.30	0.87	129	129	0	0.018
Deep Creek Range (northwest side) fault zone	3.00E+11	11	15	165	1.65E+12	0.2	0.02	9.9E+22	6.2	5	1	2.30	1.30	121	121	0	0.016
Morgan fault, central section	3.00E+11	3	15	45	4.5E+11	0.2	0.02	2.7E+22	5.7	5	1	2.30	6.56	88	88	0	0.016
Crater Bench faults	3.00E+11	16	15	240	2.4E+12	0.2	0.02	1.4E+23	6.4	5	1	2.30	0.87	137	137	0	0.016
Faults on eastern side of Curlew Valley	3.00E+11	13	15	195	1.95E+12	0.2	0.02	1.2E+23	6.3	5	1	2.30	1.09	132	132	0	0.015
Martin Ranch fault	3.00E+11	26	15	390	3.9E+12	0.8	0.08	9.4E+23	6.6	5	1	2.30	0.53	161	161	0	0.015
Crawford Mountains (west side) fault	3.00E+11	22	15	330	3.3E+12	0.2	0.02	2.0E+23	6.5	5	1	2.30	0.63	153	153	0	0.015
Spruce Mountain Ridge fault zone	3.00E+11	31	15	465	4.65E+12	0.2	0.02	2.8E+23	6.7	5	1	2.30	0.44	175	175	0	0.014
Clear Lake fault zone	3.00E+11	36	15	540	5.4E+12	0.2	0.02	3.2E+23	6.7	5	1	2.30	0.38	177	177	0	0.014
Silver Island Mountains (southwest side) fault	3.00E+11	2	15	30	3E+11	0.2	0.02	1.8E+22	5.5	5	1	2.30	13.52	92	92	0	0.013
Bear River fault zone	3.00E+11	20	15	300	3E+12	0.2	0.02	1.8E+23	6.5	5	1	2.30	0.69	161	161	0	0.013
Whitney Canyon fault	3.00E+11	17	15	255	2.55E+12	0.2	0.02	1.5E+23	6.4	5	1	2.30	0.82	153	153	0	0.013
Little Valley faults	3.00E+11	19	15	285	2.85E+12	0.2	0.02	1.7E+23	6.5	5	1	2.30	0.73	161	161	0	0.013
East Cache fault zone, central section	3.00E+11	5	15	75	7.5E+11	0.8	0.08	1.8E+23	5.9	5	1	2.30	3.25	121	121	0	0.012
Southern Spring Valley fault zone	3.00E+11	40	15	600	6E+12	0.2	0.02	3.6E+23	6.8	5	1	2.30	0.34	225	225	0	0.012
Snow Lake graben	3.00E+11	25	15	375	3.75E+12	0.2	0.02	2.3E+23	6.6	5	1	2.30	0.55	193	193	0	0.011
Eastern Bear Lake fault, southern section	3.00E+11	6	15	90	9E+11	0.8	0.08	2.2E+23	6.0	5	1	2.30	2.60	161	161	0	0.008
Scipio Valley faults	3.00E+11	7	15	105	1.05E+12	0.2	0.02	6.3E+22	6.1	5	1	2.30	2.16	169	169	0	0.008
Scipio faults	3.00E+11	13	15	195	1.95E+12	0.2	0.02	1.2E+23	6.3	5	1	2.30	1.09	185	185	0	0.008
Pavant Range fault	3.00E+11	14	15	210	2.1E+12	0.2	0.02	1.3E+23	6.3	5	1	2.30	1.00	193	193	0	0.008
Southern Snake Range fault zone	3.00E+11	28	15	420	4.2E+12	0.2	0.02	2.5E+23	6.6	5	1	2.30	0.49	225	225	0	0.008
Unnamed fault on west side of Snake Range	3.00E+11	26	15	390	3.9E+12	0.2	0.02	2.3E+23	6.6	5	1	2.30	0.53	241	241	0	0.007
Stinking Springs fault	3.00E+11	4	15	60	6E+11	0.2	0.02	3.6E+22	5.8	5	1	2.30	4.34	161	161	0	0.006
Rock Creek fault	3.00E+11	6	15	90	9E+11	0.8	0.08	2.2E+23	6.0	5	1	2.30	2.60	209	209	0	0.005
Sugarville area faults	3.00E+11	4	15	60	6E+11	0.2	0.02	3.6E+22	5.8	5	1	2.30	4.34	185	185	0	0.005

Earthquake Search Results

Circle Search Earthquakes = 24

Radius: 165 km

Date Range: 1000 - 2007

Magnitude Range: 4.5 - 9.0

Circle Center Point Latitude: 40.852N   Longutude: -112.749W

Note:

Type of Magnitude *UK is assumed to be ML* based on occurrence time

	CAT	YEAR	MO	DAY	ORIG TIME	LAT	LONG	DEPTH (km)	MAGNITUDE	DIST (km)	TYPE OF MAGNITUDE	Mw
1	SRA	1934	3	12	150540	41.5	-112.5		6.6	74	UKSRA	6.8
2	SRA	1934	3	12	1729	41.5	-112.5		4.8	74	MLSRA	4.8
3	SRA	1934	3	12	1812	41.5	-112.5		5.1	74	MLSRA	5.1
4	SRA	1934	3	12	182013	41.5	-112.5		6	74	UKSRA	6.1
5	SRA	1934	3	15	1201	41.5	-112.5		5.1	74	MLSRA	5.1
6	SRA	1934	3	15	1346	41.5	-112.5		4.8	74	MLSRA	4.8
7	SRA	1934	4	7	216	41.5	-111.5		5.5	127	MLSRA	5.5
8	SRA	1934	4	14	212632	41.5	-112.5		5.3	74	UKSRA	5.3
9	SRA	1934	5	6	80949	41.5	-113		5.5	74	UKSRA	5.5
10	SRA	1962	8	30	133524.4	42.02	-111.74	7	5.7	156	MLSRA	5.7
11	SRA	1962	9	5	160427.8	40.72	-112.09	7	5.2	57	MLSRA	5.2
12	SRA	1963	7	17	192039.6	39.53	-111.91	7	4.9	163	mb gs	4.9
13	SRA	1966	3	17	114747.4	41.66	-111.56	7	4.6	134	MLSRA	4.6
14	SRA	1970	3	29	124040.3	41.66	-113.84	7	4.7	128	MLSRA	4.7
15	SRA	1972	3	6	133324.9	41.88	-111.61	7	4.6	148	mb gs	4.6
16	SRA	1972	10	1	194229.5	40.51	-111.35	7	4.7	124	mb gs	4.7
17	SRA	1975	3	28	23106	42.06	-112.52	5	6.1	135	mb gs	6.8
18	SRA	1975	3	29	130119.9	42.03	-112.52	7	4.7	132	mb gs	4.7
19	SRA	1975	4	2	210646.2	42.09	-112.44	6	4.7	139	mb gs	4.7
20	SRA	1975	4	7	134234.6	42.05	-112.49	6	4.6	134	mb gs	4.6
21	SRA	1978	11	30	65340.1	42.11	-112.49	4	4.7	141	MLSRA	4.7
22	SRA	1980	5	24	100336.3	39.94	-111.97	5	5	120	mb gs	5
23	SRA	1981	2	20	91301.2	40.32	-111.74	1	4.7	103	mb gs	4.7
24	SRA	1983	10	8	115753.8	40.75	-111.99	6	4.5	64	mb gs	4.5

APPENDIX C
DISPLACEMENT ANALYSES

SIMPLIFIED SEISMIC DESIGN PROCEDURE FOR GEOSYNTHETIC-LINED, SOLID-WASTE LANDFILLS

This analysis is based on the paper "Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills," A Technical Paper by J.D. Bray, E.M. Rathje, A.J. Augello, and S.M. Merry, published in Geosynthetics International 1998, Vol. 5, Nos. 1-2, Pages 203-235

Base Sliding

Description	Value & Source	
Name of Landfill	Wasatch Regional Landfill	
Section Details	A-A' **Option 1**	
Fault & Earthquake Description & Parameters:		
Near-field fault considered	Stansbury Fault	
Magnitude of Earthquake (M_w) - with 10% or 2% probability of exceedance in 50 years (as locally required)	6.9	*USGS*
Epicentral Distance from site	14 miles 22.58 km	*USGS*
Estimated Max. Horiz. Accel. (MHA_{Rock})	0.27 .g	*Bray-Fig. 2a*
Mean Time Period of Earthquake (T_m)	0.53 sec	*Rathje et al., 1998; Bray Fig. 2b*
Significant Duration (D_{5-95})	16 sec	*Abrahamson/Silva, 1996; Bray Fig. 2c*
Horiz. Earthquake Coeff. For pseudostatic stabiltiy analysis (k)	0.436	*Vector Analyses*
Screening for Displacement Analysis		
Yield Accel. Coeff. for Base Sliding (k_y)	0.123	*Vector Analyses*
Acceptable Displacement at the base due to Sliding:	300 mm	*Common Practice*
Screening Logic: *Is $k > k_y$?*	Yes	
Screening Result	**Displacements in excess of 300mm at the base is expected; Displacement Analysis is advised.**	

Base Sliding - Permanent Displacement Calculations		
Max. Height of Proposed Landfill (H)	300 ft 91.5 m	*As Designed*
Shear Wave Velocity - Top third (V_T)	200 m/sec	*Kavazanjian et al. 1996; Bray-Fig. 3*
- Middle third (V_M)	310 m/sec	
- Bottom third (V_B)	340 m/sec	
Avergage Shear Wave Velocity ($V_{s\text{-}avg}$)	283 m/sec	$=V_T+V_M+V_B/3$
Fundamental Period of Landfill (T_s)	1.3 sec	$= 4H/V_{s\text{-}avg}$
Time Period Ratio - T_s/T_m	2.4	
Nonlinear Response Factor of Waste (NRF = MHA_{Site}/MHA_{Rock})	1.12	*= 0.6225+0.9196 * EXP(-MHA $_{Rock}$/ /g/0.4449)*
Max. Horiz. Accel. for the Site (MHA_{Site})	0.30 .g	$= NRF * MHA_{Rock}$
For 16% Probability of Exceedance -		
Normalized Maximum Horizontal Equivalent Acceleration ($MHEA_{Norm}$)	0.38 .g	*Bray-Fig. 6;* $=MHEA_{Base}/MHA_{Site}$
Maximum Horizontal Equivalent Acceleration ($MHEA_{Base}$)	0.12 .g	$= MHEA_{Norm} * MHA_{Site}$
Max. Seismic Accel. Coefficient (k_{max})	0.12	$k_{max} = MHEA_{Base}/g$
Acceleration Ratio (k_y/k_{max})	1.07	
Normalized Sliding Displacemnt. (U_{Norm})	0.6 mm/s	*Bray-Fig. 11*
Permanent Displacement (U) - @ probability of 16% Exceedance	1.11 mm **0.04 inch**	$U= U_{Norm} * D_{5\text{-}95} * k_{max}$
For 50% Probability of Exceedance -		
Normalized Maximum Horizontal Equivalent Acceleration ($MHEA_{Norm}$)	0.27	*Bray Fig. 6;* $= EXP(-0.624-0.7831*ln(T_s/T_m))$
Maximum Horizontal Equivalent Acceleration ($MHEA_{Base}$)	0.08 .g	$= MHEA_{Norm} * MHA_{Site}$
Max. Seismic Accel. Coefficient (k_{max})	0.08	$k_{max} = MHEA_{Base}/g$
Acceleration Ratio (k_y/k_{max})	1.51	
Normalized Sliding Displacemnt. (U_{Norm})	0.00 mm/s	*Bray-Fig. 11;* $=10^{\wedge}(1.87-3.477 * k_y/k_{max})$
Permanent Displacement (U) - @ probability of 50% Exceedance	0.01 mm **0.00 inch**	$U= U_{Norm} * D_{5\text{-}95} * k_{max}$

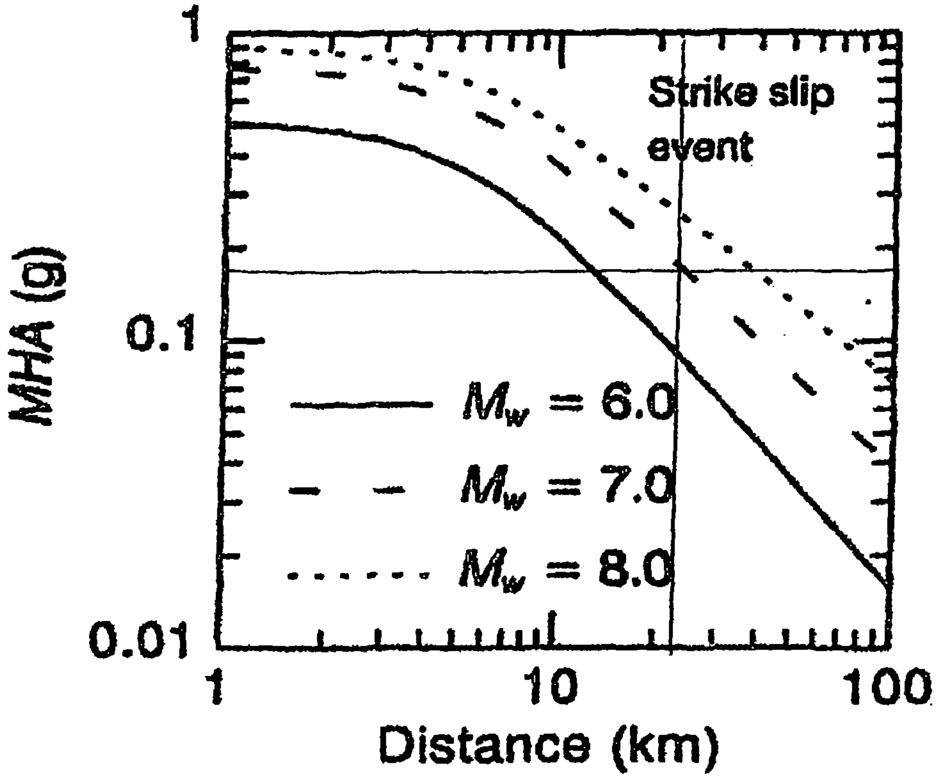
SIMPLIFIED SEISMIC DESIGN PROCEDURE FOR GEOSYNTHETIC-LINED, SOLID-WASTE LANDFILLS

This analysis is based on the paper "Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills," A Technical Paper by J.D. Bray, E.M. Rathje, A.J. Augello, and S.M. Merry, published in Geosynthetics International 1998, Vol. 5, Nos. 1-2, Pages 203-235

Base Sliding

Description	Value & Source	
Name of Landfill	Wasatch Regional Landfill	
Section Details	A-A' **Option 2**	
Fault & Earthquake Description & Parameters:		
Near-field fault considered	Stansbury Fault	
Magnitude of Earthquake (M_w) - with 10% or 2% probability of exceedance in 50 years (as locally required)	6.9	*USGS*
Epicentral Distance from site	14 miles 22.58 km	*USGS*
Estimated Max. Horiz. Accel. (MHA_{Rock})	0.27 .g	*Bray-Fig. 2a*
Mean Time Period of Earthquake (T_m)	0.53 sec	*Rathje et al., 1998; Bray Fig. 2b*
Significant Duration (D_{5-95})	16 sec	*Abrahamson/Silva, 1996; Bray Fig. 2c*
Horiz. Earthquake Coeff. For pseudostatic stabiltiy analysis (k)	0.436	*Vector Analyses*
Screening for Displacement Analysis		
Yield Accel. Coeff. for Base Sliding (k_y)	0.175	*Vector Analyses*
Acceptable Displacement at the base due to Sliding:	300 mm	*Common Practice*
Screening Logic: *Is $k > k_y$?*	Yes	
Screening Result	**Displacements in excess of 300mm at the base is expected; Displacement Analysis is advised.**	

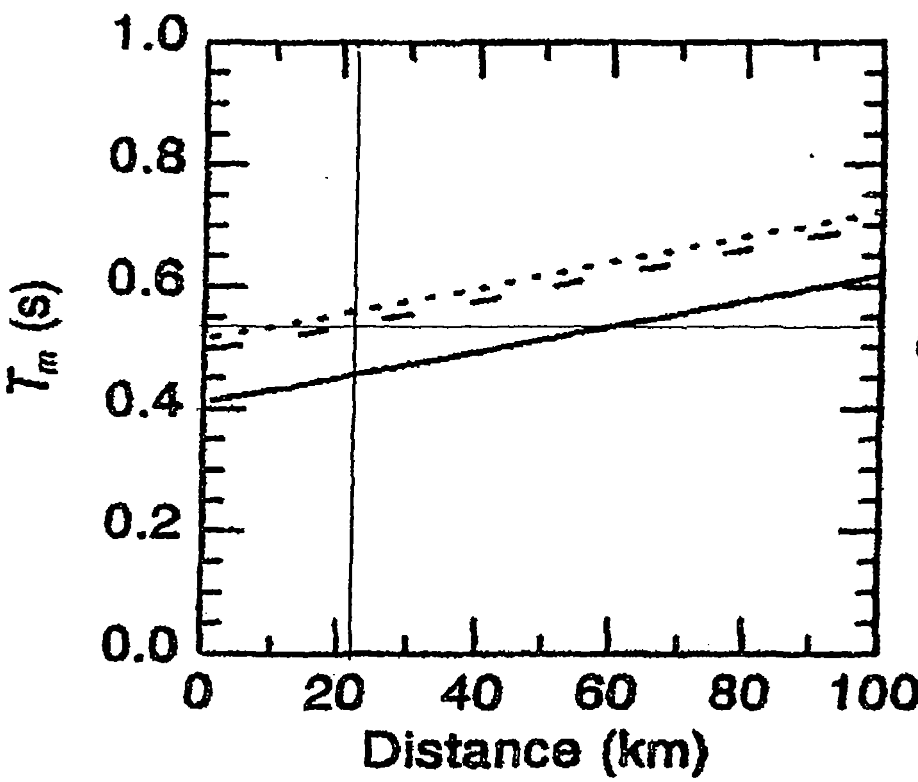
Base Sliding - Permanent Displacement Calculations		
Max. Height of Proposed Landfill (H)	300 ft 91.5 m	*As Designed*
Shear Wave Velocity - Top third (V_T)	200 m/sec	*Kavazanjian et al. 1996; Bray-Fig. 3*
- Middle third (V_M)	310 m/sec	
- Bottom third (V_B)	340 m/sec	
Avergage Shear Wave Velocity ($V_{s\text{-}avg}$)	283 m/sec	$=V_T+V_M+V_B/3$
Fundamental Period of Landfill (T_s)	1.3 sec	$= 4H/V_{s\text{-}avg}$
Time Period Ratio - T_s/T_m	2.4	
Nonlinear Response Factor of Waste (NRF = MHA_{Site}/MHA_{Rock})	1.12	$= 0.6225+0.9196 * EXP(-MHA_{Rock}/ /g/0.4449)$
Max. Horiz. Accel. for the Site (MHA_{Site})	0.30 .g	$= NRF * MHA_{Rock}$
For 16% Probability of Exceedance -		
Normalized Maximum Horizontal Equivalent Acceleration ($MHEA_{Norm}$)	0.38 .g	*Bray-Fig. 6;* $=MHEA_{Base}/MHA_{Site}$
Maximum Horizontal Equivalent Acceleration ($MHEA_{Base}$)	0.12 .g	$= MHEA_{Norm} * MHA_{Site}$
Max. Seismic Accel. Coefficient (k_{max})	0.12	$k_{max} = MHEA_{Base/}g$
Acceleration Ratio (k_y/k_{max})	1.52	
Normalized Sliding Displacemnt. (U_{Norm})	0.6 mm/s	*Bray-Fig. 11*
Permanent Displacement (U) - @ probability of 16% Exceedance	1.11 mm **0.04 inch**	$U= U_{Norm} * D_{5\text{-}95} * k_{max}$
For 50% Probability of Exceedance -		
Normalized Maximum Horizontal Equivalent Acceleration ($MHEA_{Norm}$)	0.30	*Bray Fig. 6;* $= EXP(-0.624-0.7831*ln(T_s/T_m))$
Maximum Horizontal Equivalent Acceleration ($MHEA_{Base}$)	0.09 .g	$= MHEA_{Norm} * MHA_{Site}$
Max. Seismic Accel. Coefficient (k_{max})	0.09	$k_{max} = MHEA_{Base/}g$
Acceleration Ratio (k_y/k_{max})	1.92	
Normalized Sliding Displacemnt. (U_{Norm})	0.00 mm/s	*Bray-Fig. 11;* $=10^{\wedge}(1.87-3.477 *k_y/k_{max})$
Permanent Displacement (U) - @ probability of 50% Exceedance	0.00 mm **0.00 inch**	$U= U_{Norm} * D_{5\text{-}95} * k_{max}$



1
0.1
0.01
MHA (g)
1
10
100
Distance (km)
Strike slip event
M_w = 6.0
M_w = 7.0
M_w = 8.0

(a)

1.24



1.0
0.8
0.6
0.4
0.2
0.0
T_m (s)
0
20
40
60
80
100
Distance (km)

(b)

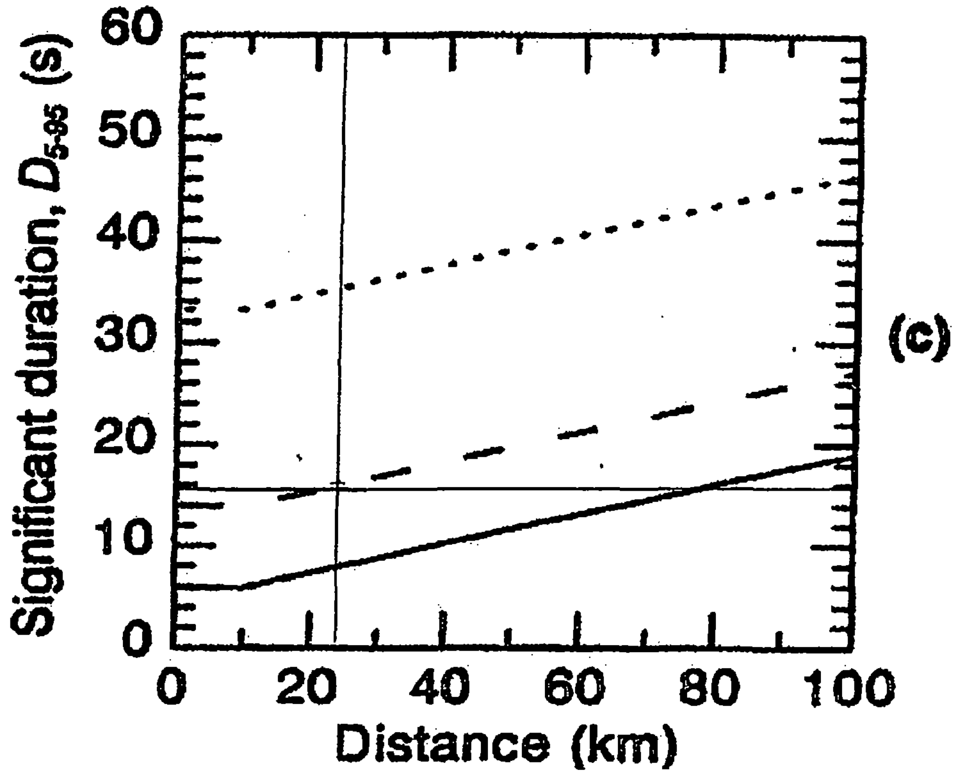


Figure 2. Simplified Characterization of earthquake rock motions: (a) intensity, MHA for strike-slip faults (for reverse faults, use 1.3xMHA for Mw ≥ 6.4 & 1.64xMHA for Mw = 6.0, with linear interpolation for 6.0 < Mw < 6.4) (Abrahamson & Silva, 1997); (b) frequency content, Tm (Rathje et al., 1998); (c) duration, $D_{5\text{-}95}$ (Abrahamson & Silva, 1996).

1.42
0.06

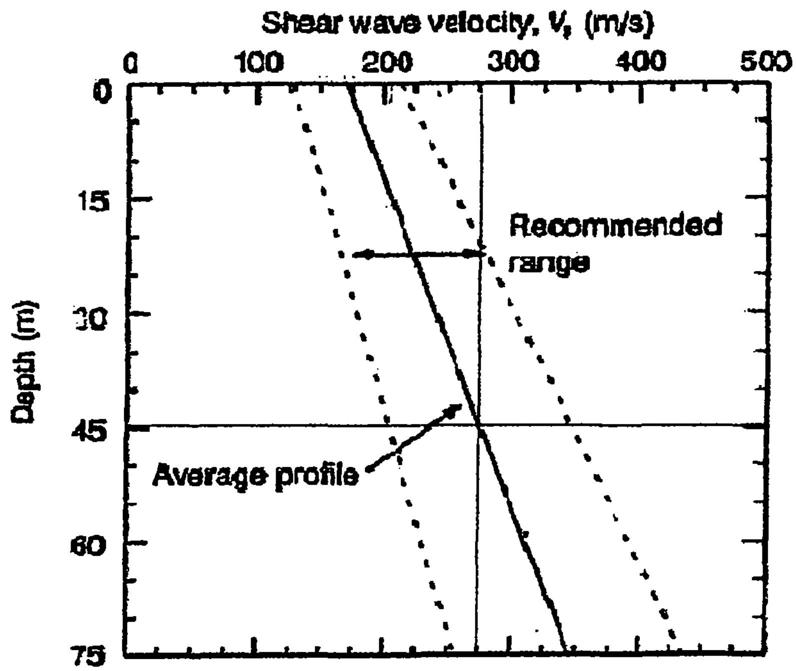


Figure 3. Shear wave velocity profiles for municipal solid-waste (after Kavazanjian et al., 1996)

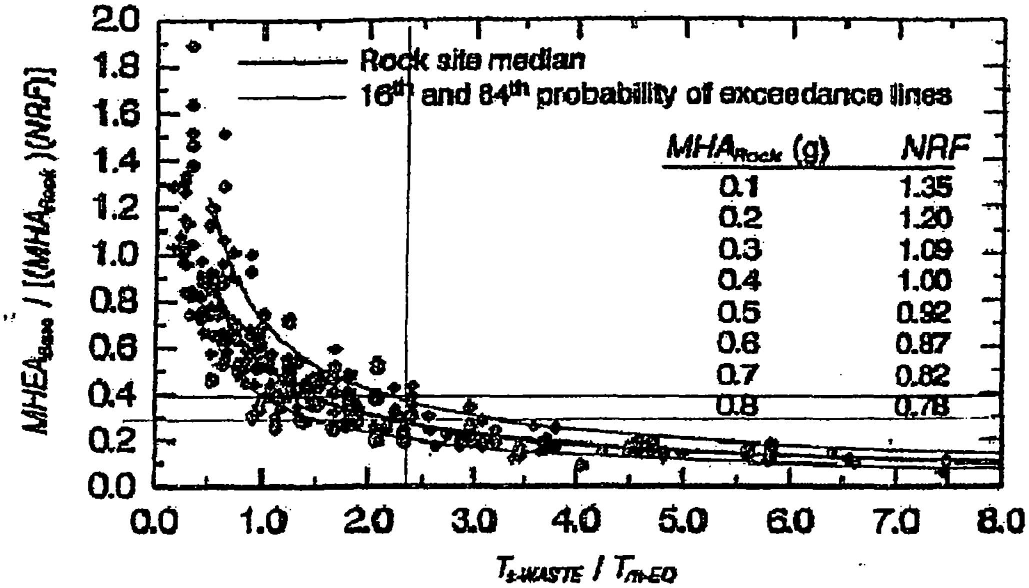


Figure 6. Normalized maximum horizontal equivalent acceleration for base sliding versus normalized fundamental period of waste fill (adapted from Bray & Rathje, 1998).

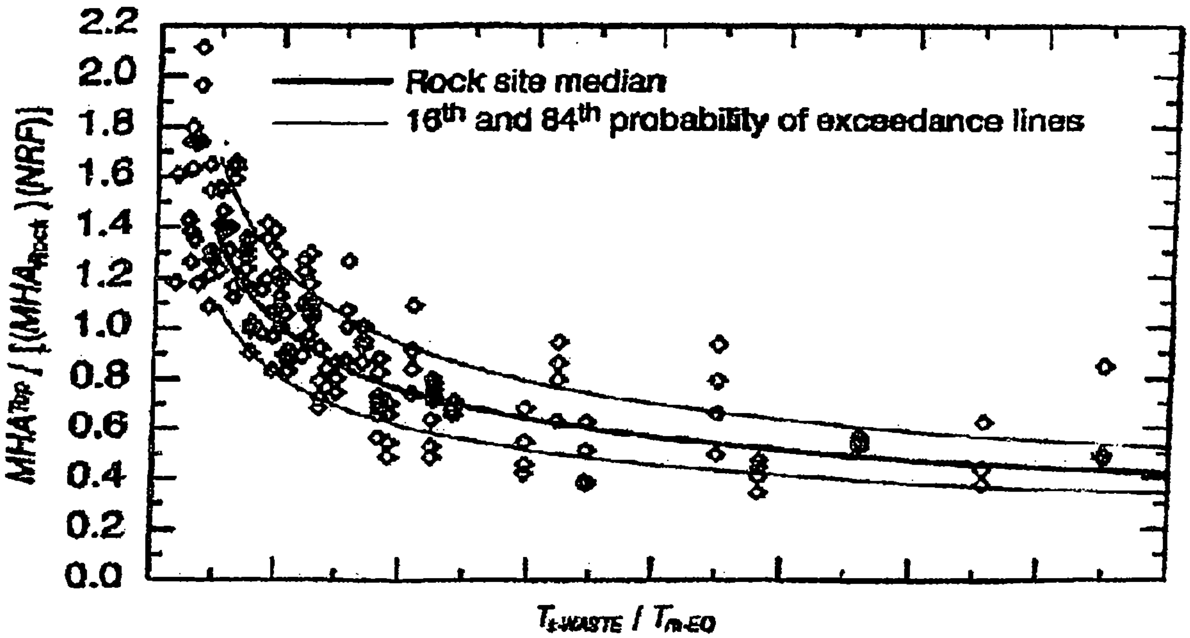


Figure 8. Normalized maximum horizontal acceleration at the top versus normalized fundamental period of waste fill (adapted from Bray & Rathje, 1998).

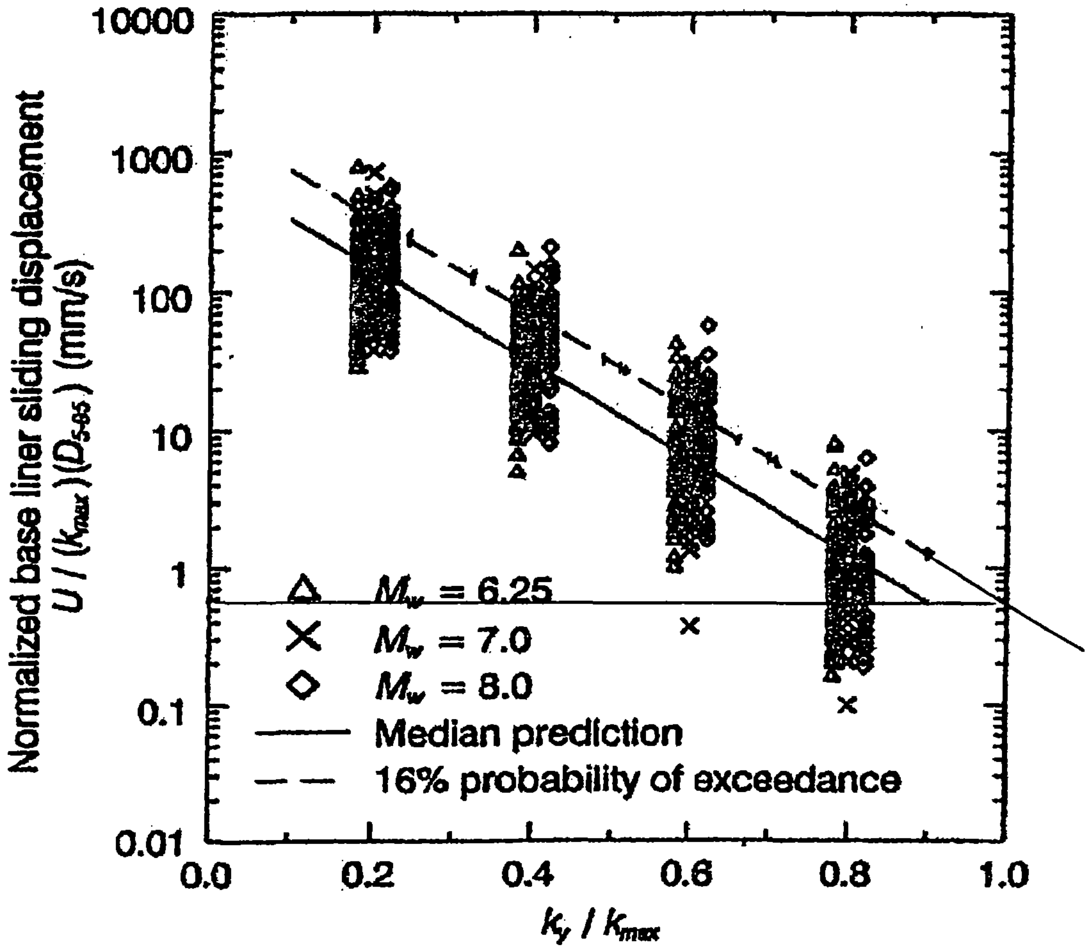


Figure 11. Normalized base liner sliding displacements
(from Bray & Rathje, 1998)

References:

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APPENDIX D
STABILITY ANALYSES RESULTS

Infinite Slope Method of Cover Slope Stability Analysis
Thiel and Stewart (1993)
Spreadsheet Modified 8/08

Wasatch Regional Landfill DMW
4 to 1 slopes Feb-09
Within Vegetative Layer (silty sand)

	During Heavy Rainfall	Without Heavy Rainfall
Slope Angle, B, (degrees)	14.03	14.03
Ave. Depth of Solution in Cover Layer (ft.)	0*	0
Topsoil Thickness, (ft.)	0	0
Cover Soil Layer Thickness, (ft.)	2.5	2.5
Topsoil Saturated Unit Weight, (pcf)	0	0
Cover Layer Total Unit Wt., (pcf)	100	100
Cover Layer Saturated Unit Weight., (pcf)	115	115
Solution Unit Wt. (pcf)	62.4	62.4
Interface Friction, phi, (degrees)	30	30
Interface Adhesion (psf)	0	0
Earthquake Coef., Ce, (%g)	0.15	0.15
Gas Pressure (psf)	0	0

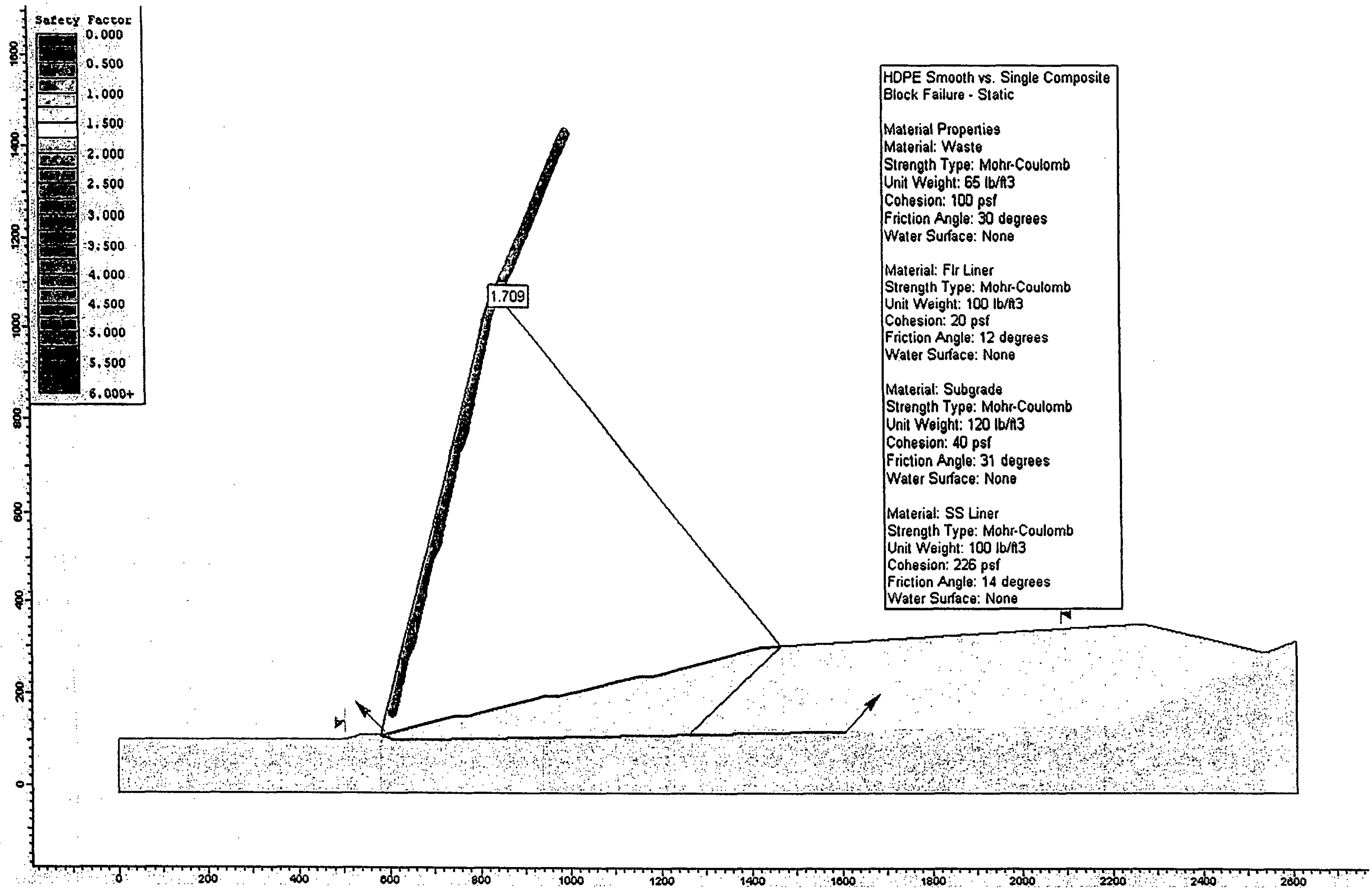
* ET cover is not expected to fully saturate

Sin B	0.2424	0.2424
Cos B	0.9702	0.9702
Tan phi	0.5774	0.5774
Tan B	0.2499	0.2499

STATIC Without Gas Pressure		
Resisting Strength (psf)	140.0	140.0
Driving Stress (psf)	60.6	60.6
Factor of Safety	2.31	2.31

PSEUDO-STATIC Without Gas Pressure		
Resisting Stress (psf)	134.8	134.8
Driving Stress (psf)	97.0	97.0
Factor of Safety	1.39	1.39

Thiel, R.S., and Stewart, M.G., 1993,"Geosynthetic Landfill Cover Design Methodology and Construction Experience in the Pacific Northwest", *Proceedings of Geosynthetics '93, IFAI, Vo. 3.*



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6.000+
1.709
HDPE Smooth vs. Single Composite
Block Failure - Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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1000
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1400
1600
1800
2000
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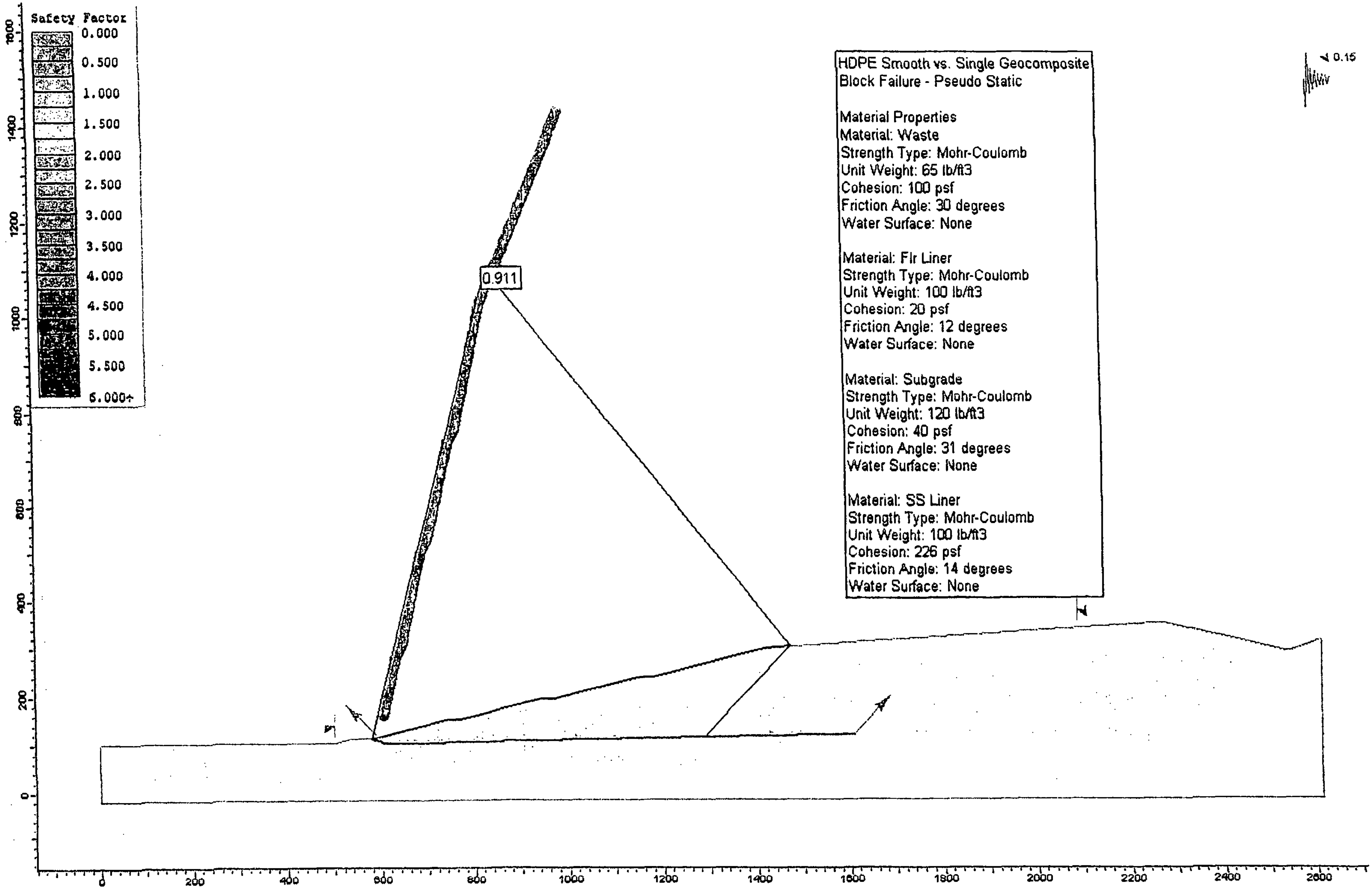
2400
2600



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HDPE Smooth vs. Single Geocomposite
Block Failure - Pseudo Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
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Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
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Friction Angle: 12 degrees
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Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
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Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
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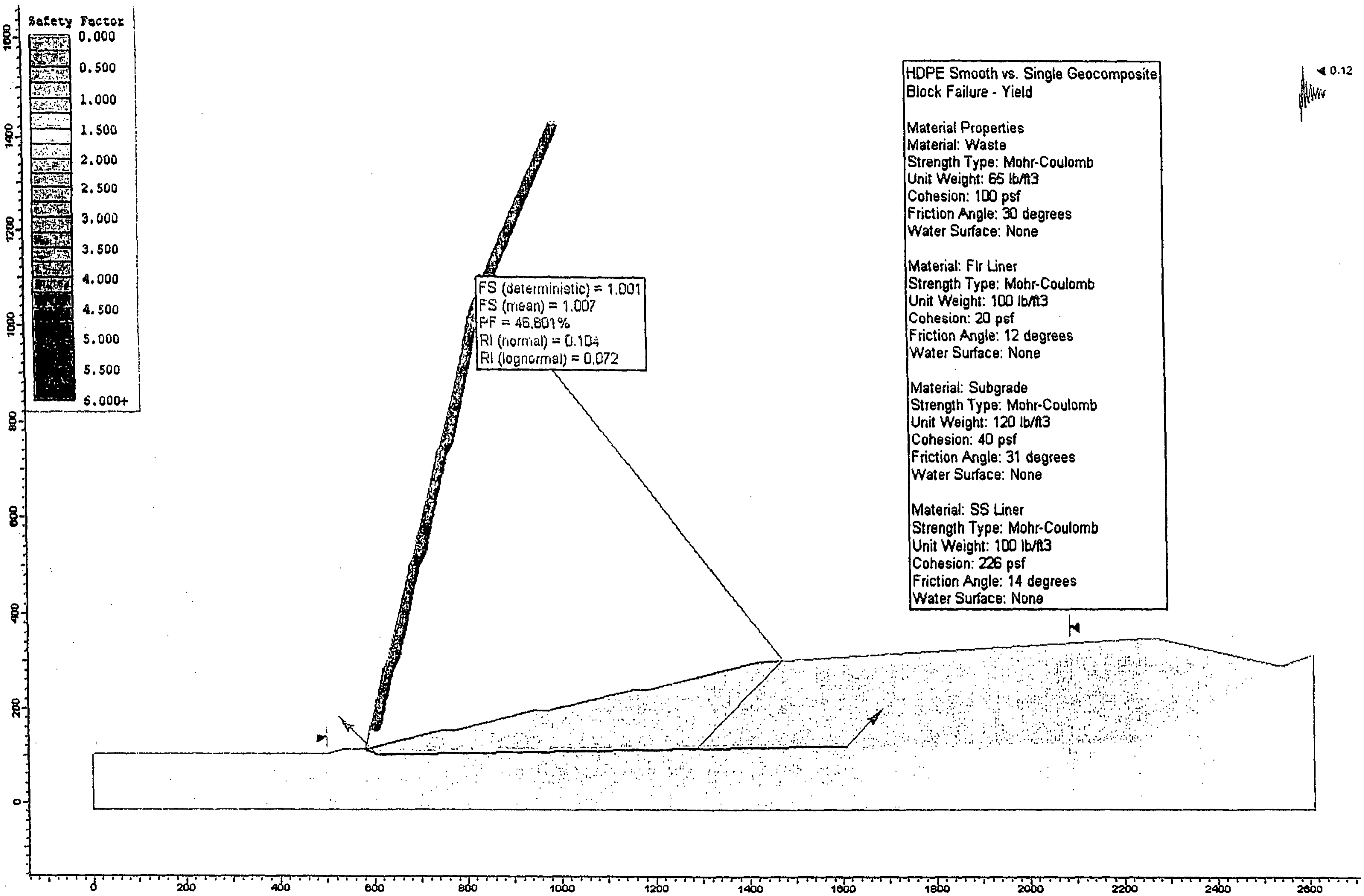
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6.000+
HDPE Smooth vs. Single Geocomposite
Block Failure - Yield
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
FS (deterministic) = 1.001
FS (mean) = 1.007
PF = 46.801%
RI (normal) = 0.104
RI (lognormal) = 0.072
0.12
1600
1400
1200
1000
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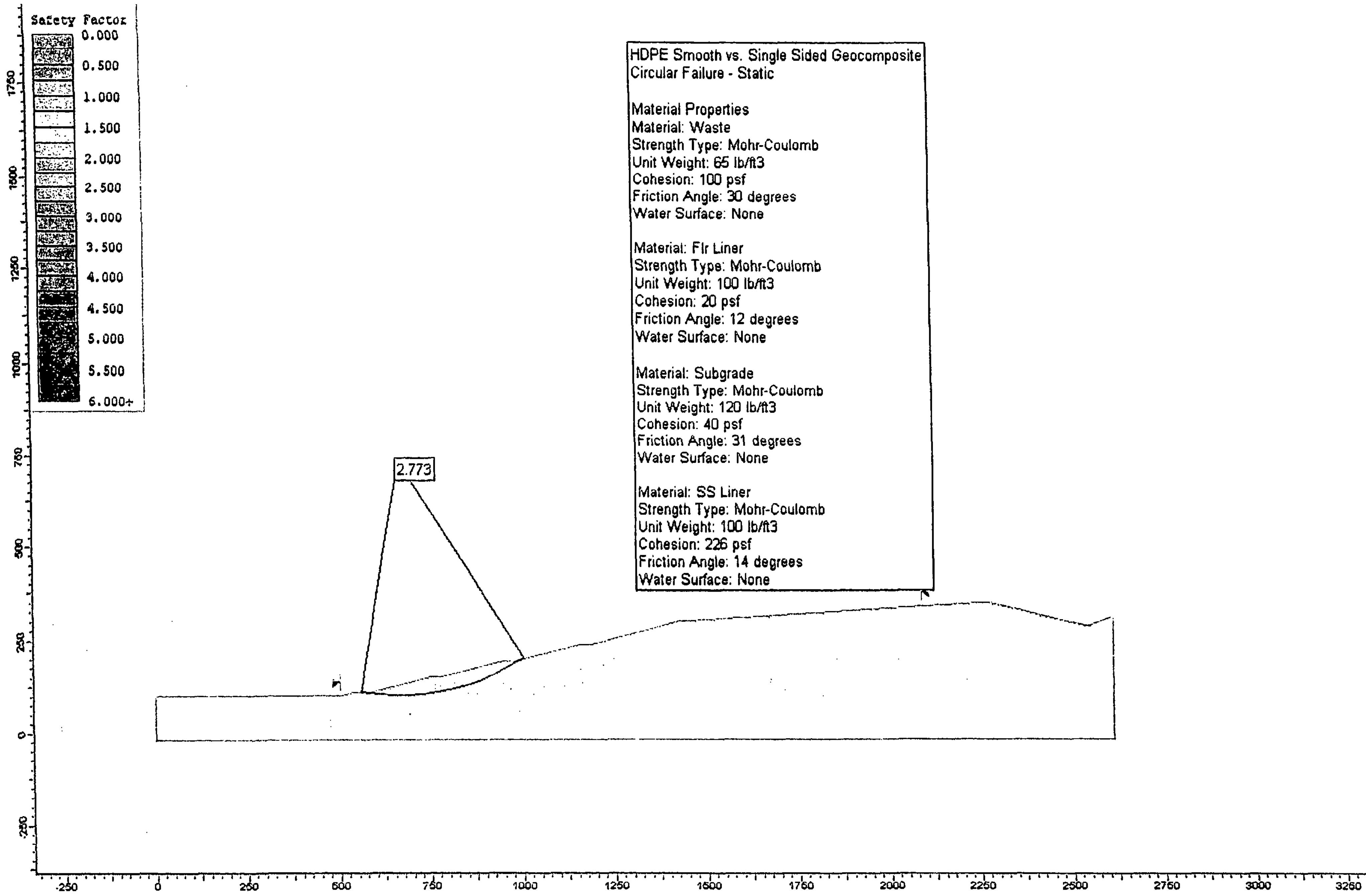

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5.500
6.000+
HDPE Smooth vs. Single Sided Geocomposite
Circular Failure - Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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1500
1250
1000
750
500
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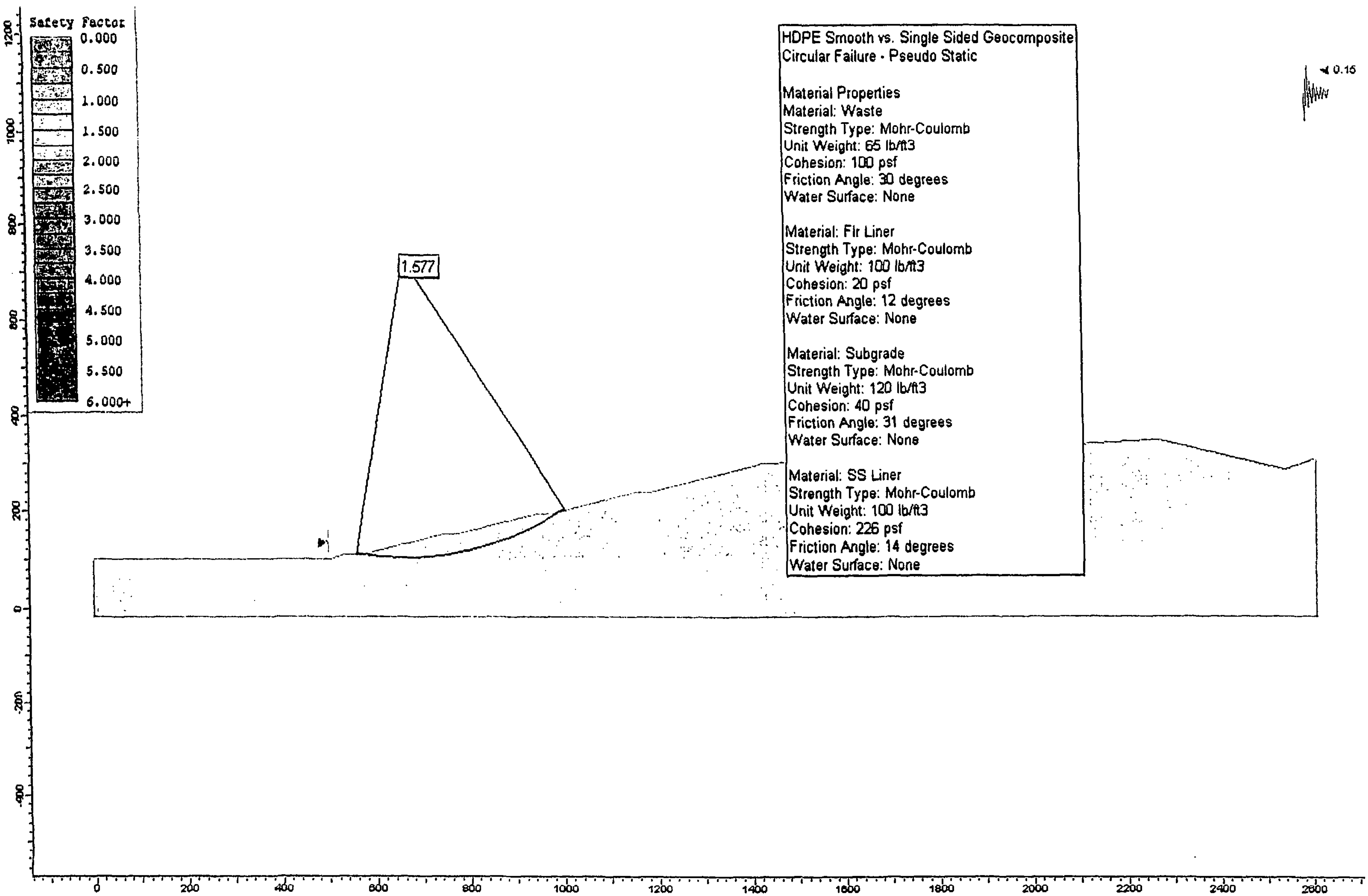

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5.500
6.000+
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HDPE Smooth vs. Single Sided Geocomposite
Circular Failure - Pseudo Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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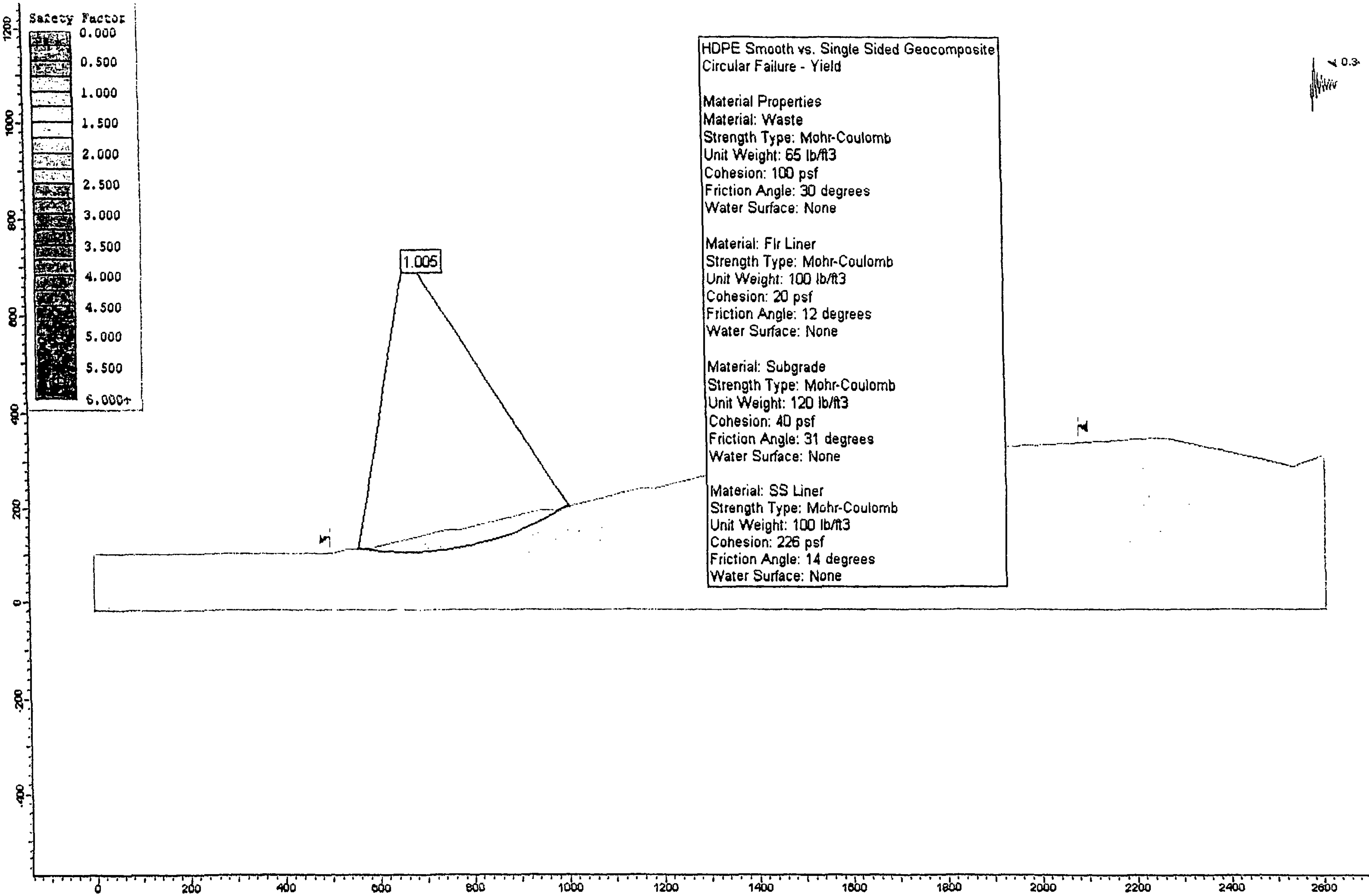
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6.000+
1.005
HDPE Smooth vs. Single Sided Geocomposite
Circular Failure - Yield
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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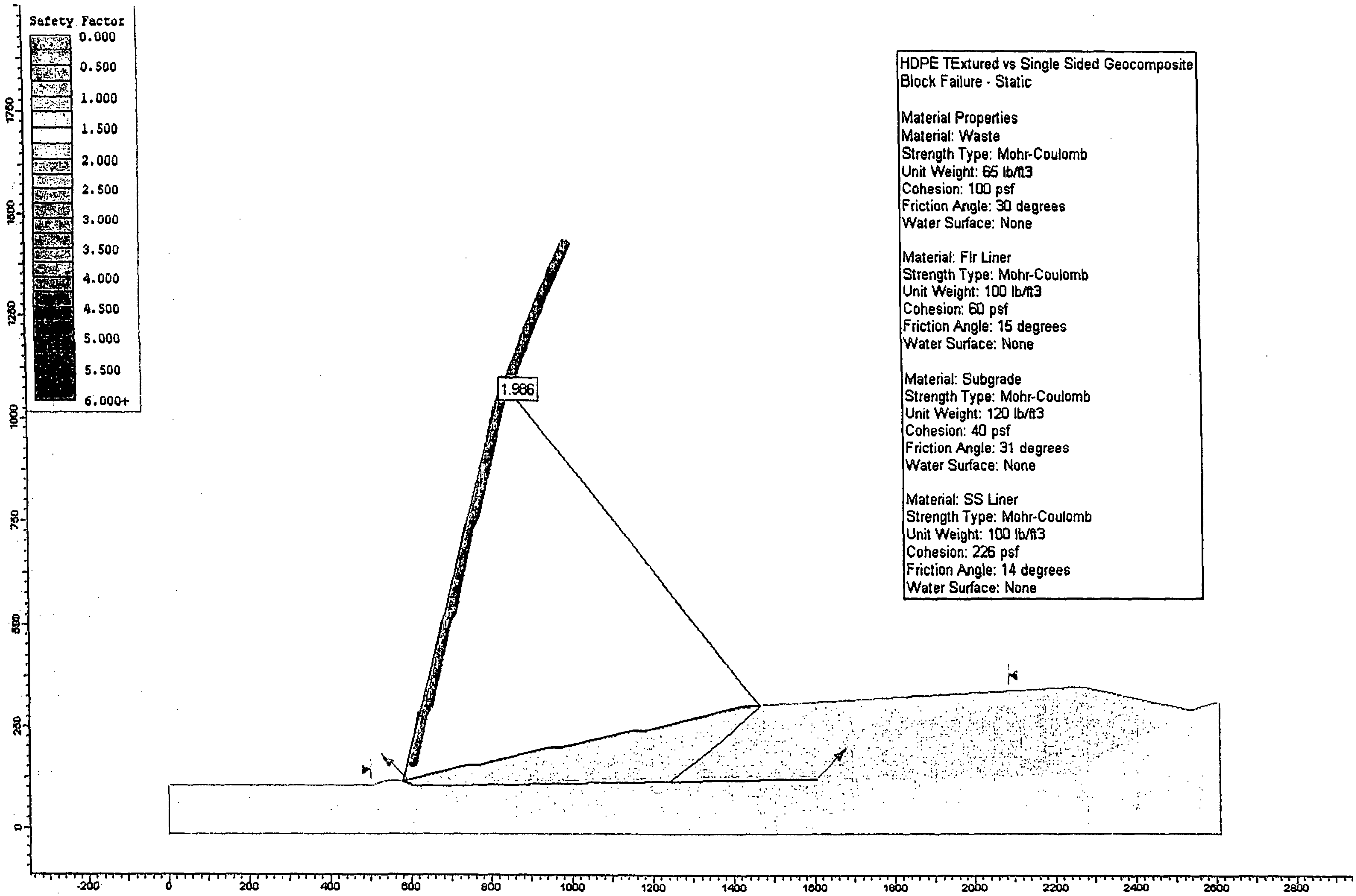

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HDPE TExtured vs Single Sided Geocomposite
Block Failure - Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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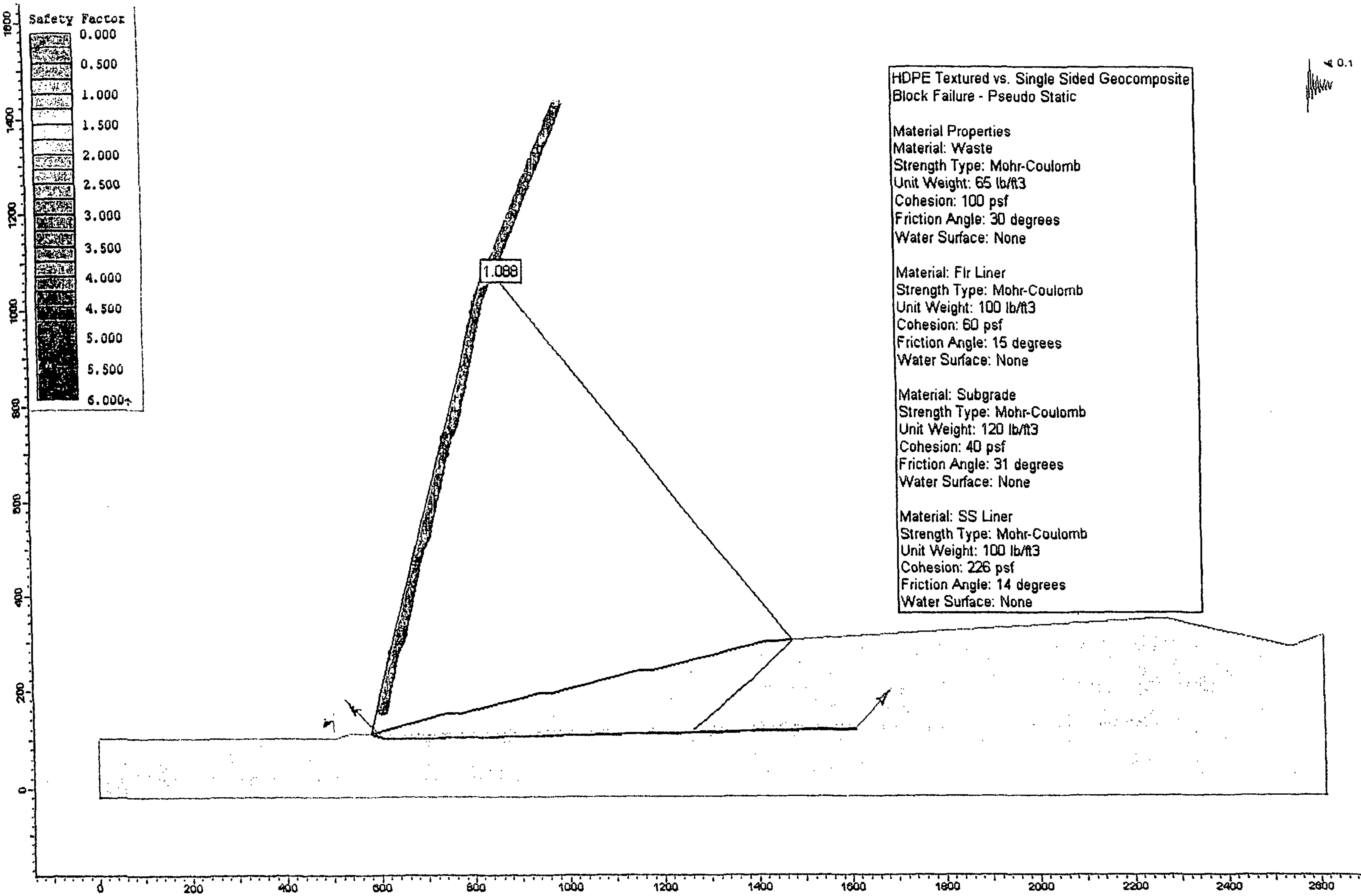
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6.000+
HDPE Textured vs. Single Sided Geocomposite
Block Failure - Pseudo Static
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
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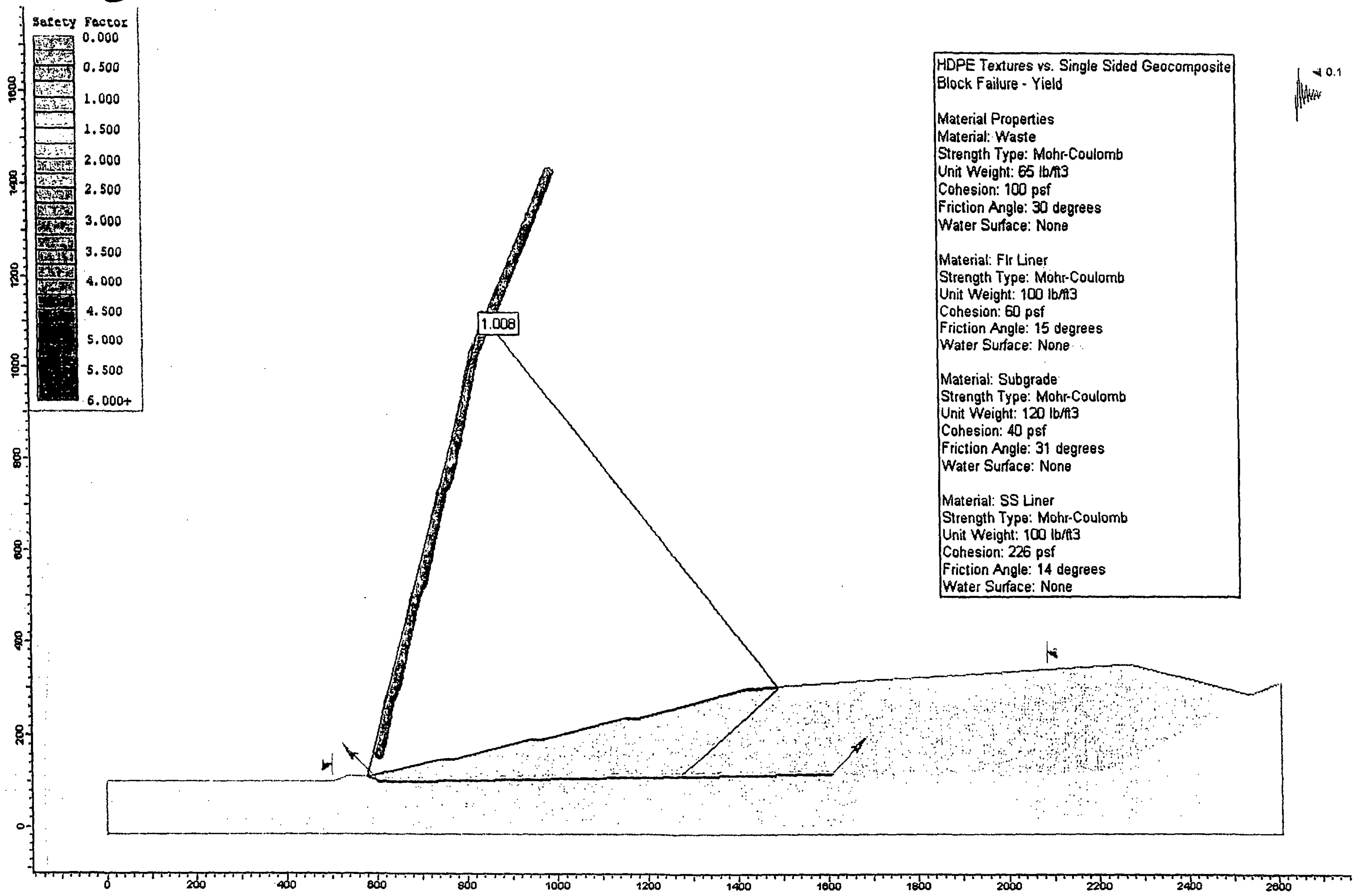

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HDPE Textures vs. Single Sided Geocomposite
Block Failure - Yield
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
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Unit Weight: 120 lb/ft3
Cohesion: 40 psf
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Friction Angle: 14 degrees
Water Surface: None
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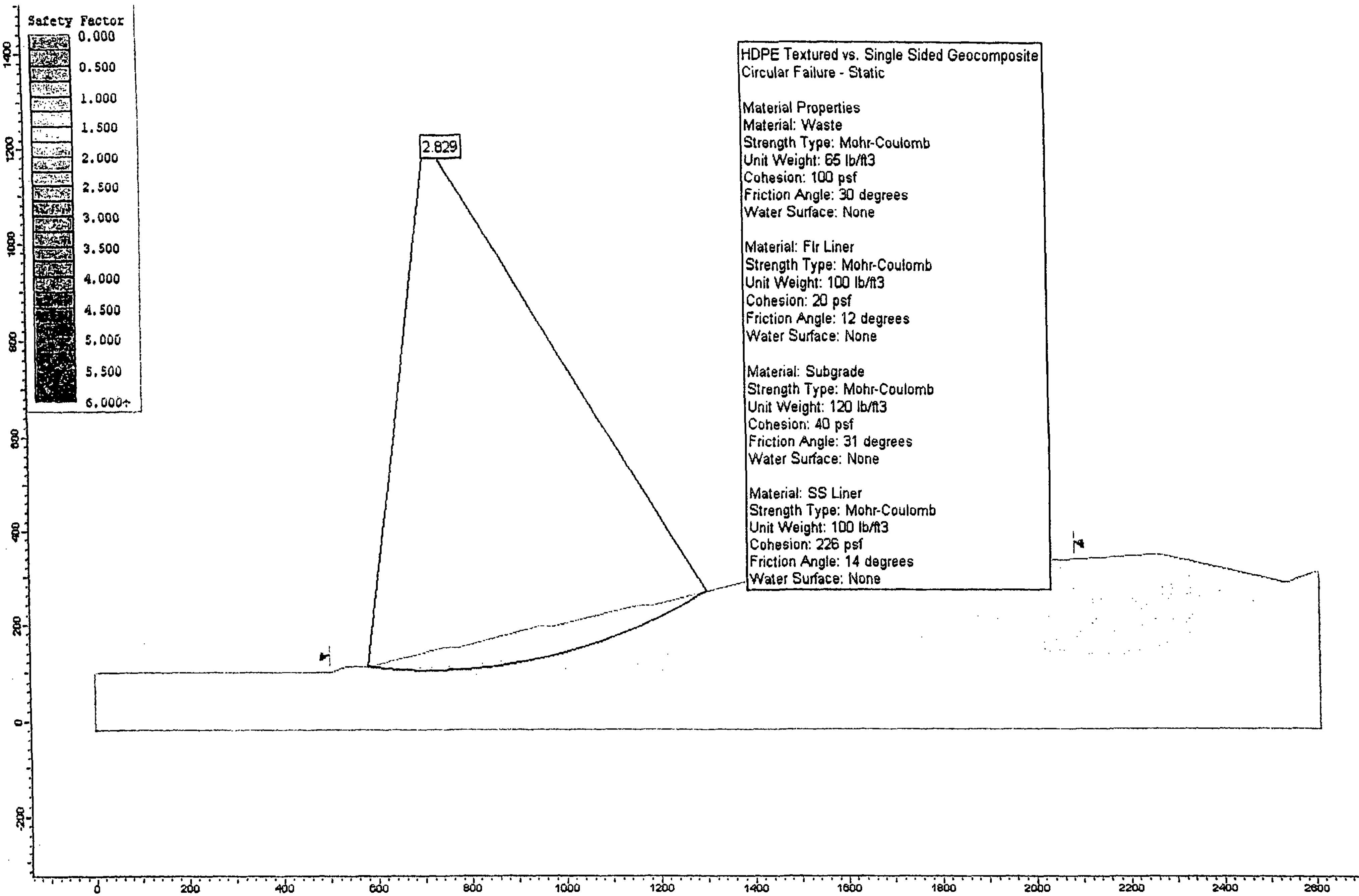
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HDPE Textured vs. Single Sided Geocomposite
Circular Failure - Static
Material Properties
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Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
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Unit Weight: 100 lb/ft3
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Friction Angle: 12 degrees
Water Surface: None
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Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
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Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
1400
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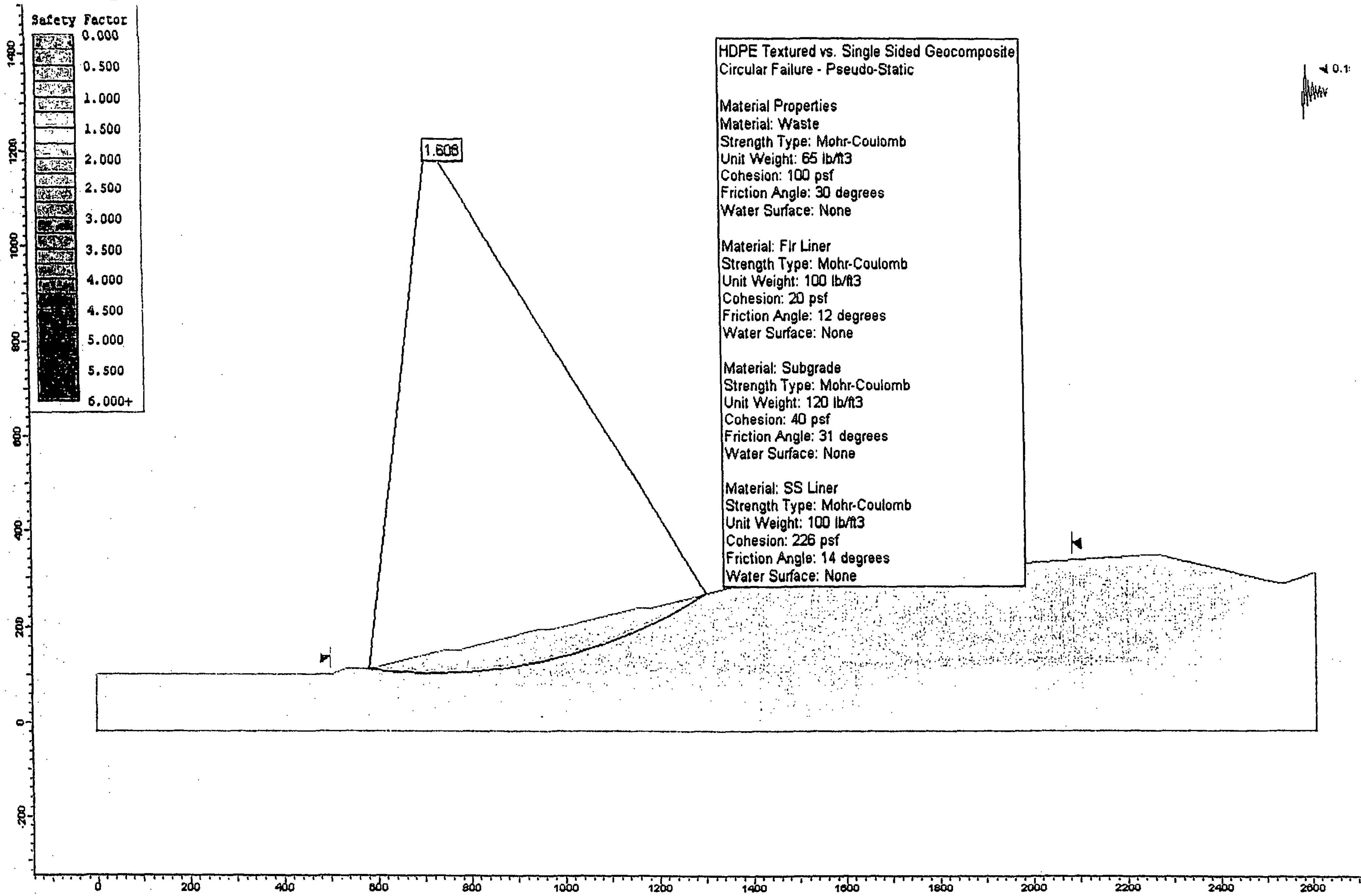

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HDPE Textured vs. Single Sided Geocomposite
Circular Failure - Pseudo-Static
Material Properties
Material: Waste
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Cohesion: 100 psf
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Water Surface: None
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Friction Angle: 31 degrees
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Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
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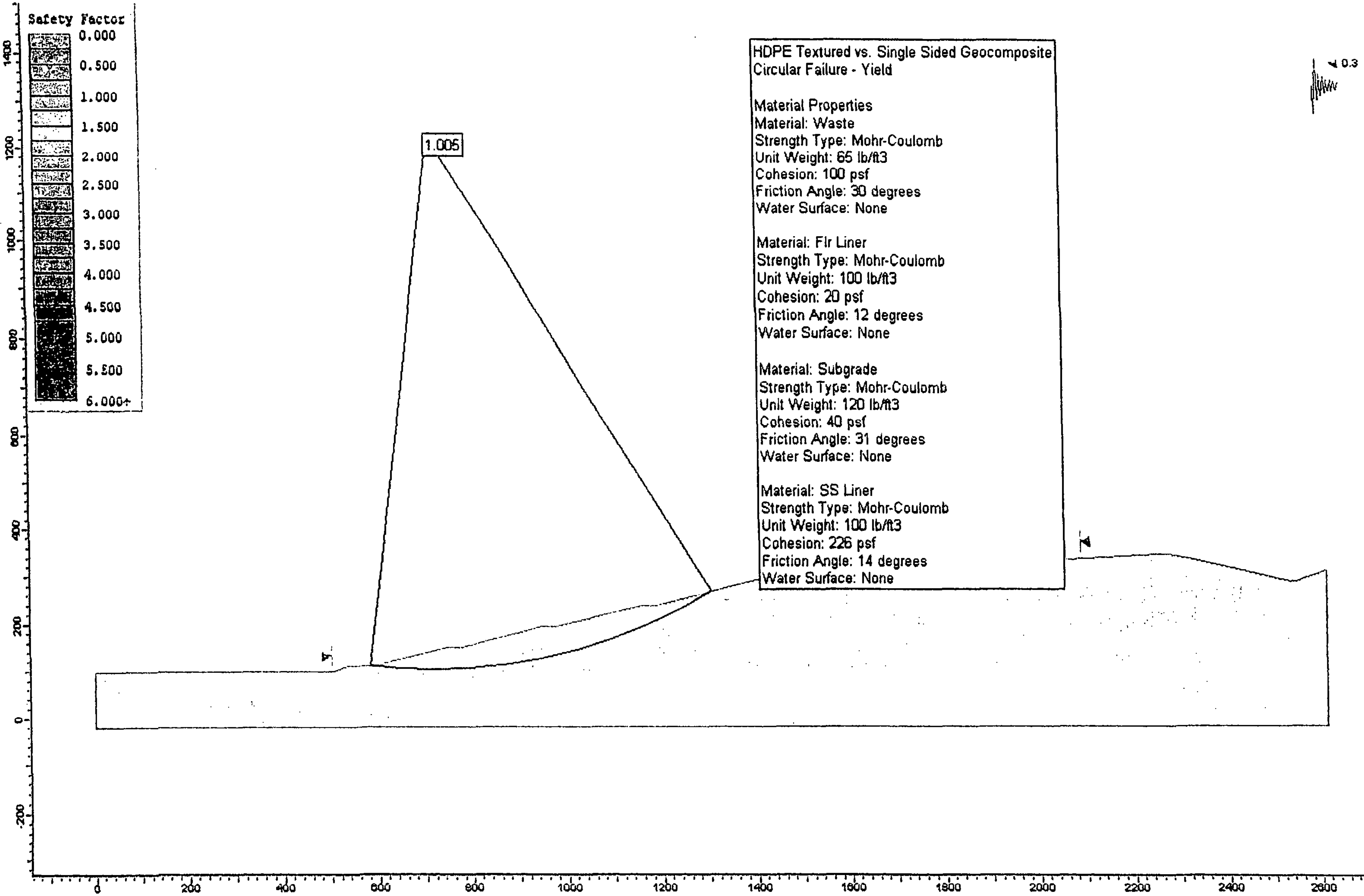

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HDPE Textured vs. Single Sided Geocomposite
Circular Failure - Yield
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
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Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
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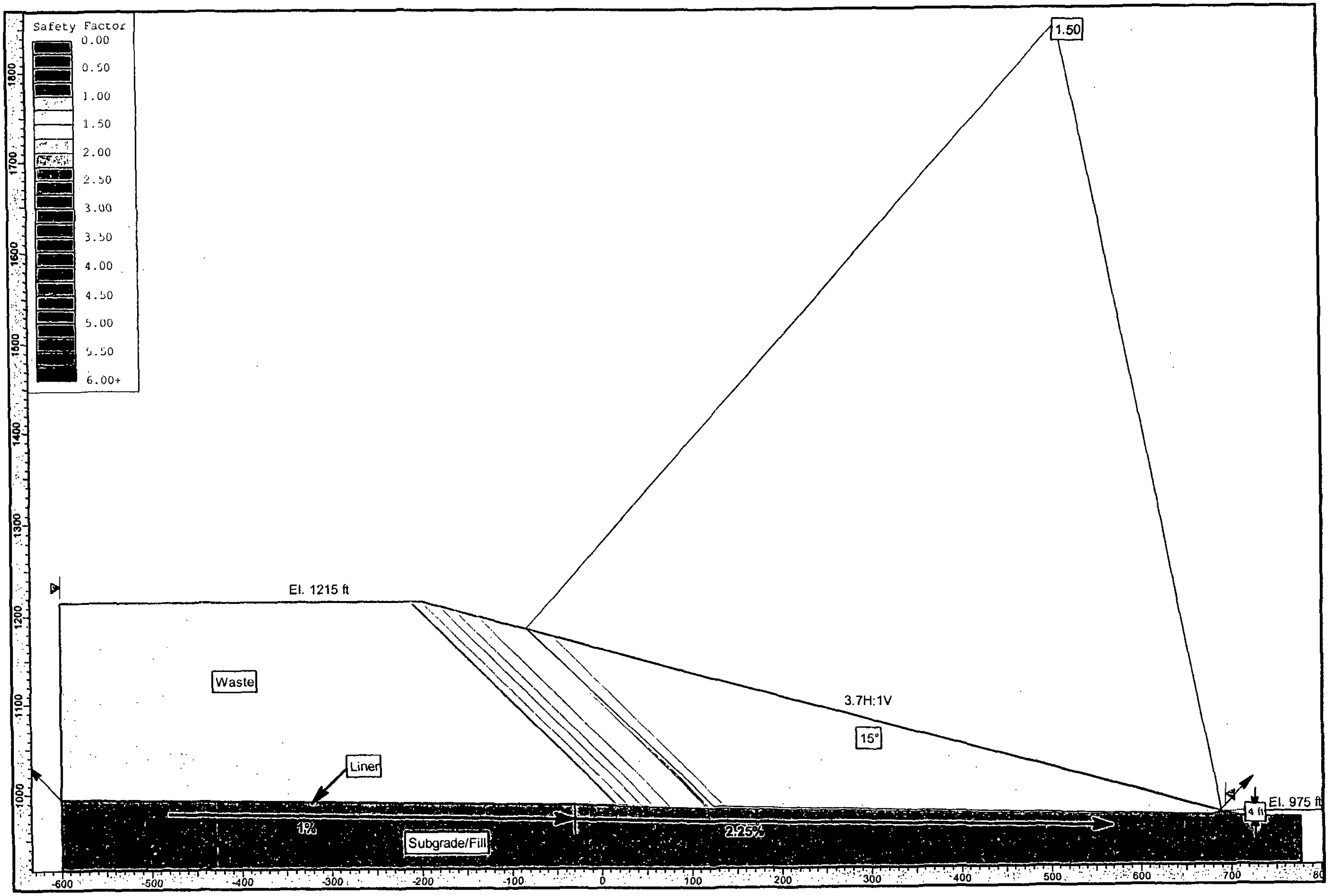


Salton Landfill – Interim Conditions

Section D: Block Failure Along Liner, Static

Transmissivity Calculations

landfilldesign.com

Design of Lateral Drainage System in Landfill - Design Calculator

Problem Statement

The ultimate transmissivity of a geocomposite drainage layer is calculated by two methods:

The first method is based on the McEnroes equations. From the McEnroes equations, the required permeability of a drainage media is calculated. Iteration procedure is used to find the required permeability such that the liquid thickness is equal to the thickness of the liquid collection layer. This permeability multiplied by the thickness of the liquid collection layer result in the required transmissivity. The ultimate geocomposite transmissivity can then be calculated by incorporating the total serviceability factor (product of safety factor and reduction factors).

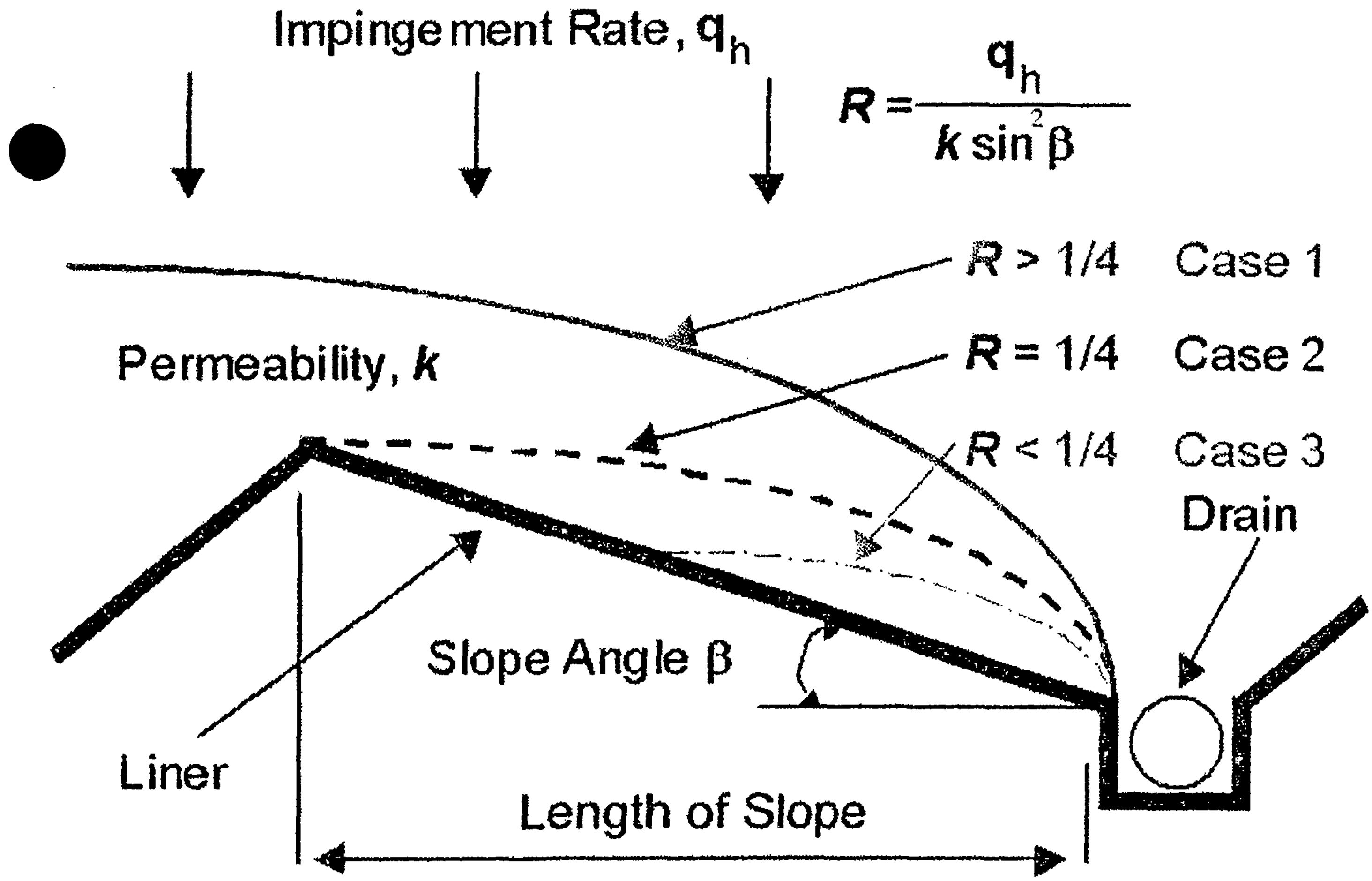
The McEnroe equation requires the input of an impingement rate (q_h), a drainage media permeability (k) and a liner slope (b). This information is used here to find the liquid thickness on the liner.

The McEnroes solutions are for three cases.

1. Case 1 is for a saw-tooth bottom, with the liquid mound overtopping the peak. (R > 1/4)
2. Case 2 has the liquid mound starting at the peak of the saw-tooth. (R = 1/4)
3. Case 3 has the mound starting below the peak of the tooth. (R > 1/4)

McEnroe Equation

$$\frac{t_{\mathrm{LCL}}}{L} = \begin{cases} \sin\beta\sqrt{R - RS + R^2S^2}\left[\dfrac{(1-A-2R)(1+A-2RS)}{(1+A-2R)(1-A-2RS)}\right]^{\frac{1}{2A}} \\[2ex] \sin\beta\,\dfrac{R(1-2RS)}{1-2R}\exp\left[\dfrac{2R(S-1)}{(1-2RS)(1-2R)}\right] \\[2ex] \sin\beta\sqrt{R - RS + R^2S^2}\,\exp\left[\dfrac{1}{B}\tan^{-1}\left(\dfrac{2RS-1}{B}\right) - \dfrac{1}{B}\tan^{-1}\left(\dfrac{2R-1}{B}\right)\right] \end{cases}$$



The second method is based on Giroud's equation. The geocomposite's ultimate transmissivity is calculated directly. Giroud's equation, with great simplicity, produces a very close solution as compared to McEnroe's equations.

Giroud Equation

$$\Theta = \mathrm{TSF}\frac{q_h L}{\sin\beta + \frac{t_{LCL}/L}{TSF}\cos^2\beta}$$

Note: Giroud's equation is based on a factor of safety applied to maximum liquid thickness to ensure unconfined flow.

Required Data

Symbol	Name	Dimensions
S	The liner slope, **S** = tan **b**	%
qh	Impingement rate	Length / Time
L	Length of slope measure horizontally	Length
tLCL	Thickness of the Liquid Collection Layer for geocomposite.	Length

FSd	Overall factor of safety for drainage
RFin	Intrusion Reduction Factor

RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1	Case 2	Case 3
S	2.68 %	1 %	1 %
q_h	7.11e-6 cm/s	1 cm/s	1 cm/s
L	42.672 m	1 m	1 m
t_{LCL}	60.96 cm	1 cm	1 cm

Factor	Case 1	Case 2	Case 3		Leachate Collection and Removal	Leachate Detection Systems
RF_{in}	1.2	1	1	[1]	1.0 - 1.2	1.0 - 1.2
RF_{cr}	3.5	1	1	[2] Calculate RF_{CR}		
RF_{cc}	1.5	1	1	[3]	1.5 - 2.0	1.1 - 1.5
RF_{bc}	1.3	1	1	[3]	1.1 - 1.3	1.1 - 1.3
FS	2	1	1	[4]	2.0 - 10.0	2.0 - 10.0

Note: The reduction factor values given correspond to the case where the seating time exceeds 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test, extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
R	$= q_h/(k \sin^2 b)$	-
Gradient	Gradient	-
θ	Transmissivity = k t_{LCL} TSF	Length^2 / Time

Case 1

McEnroe	Giroud
R = 9.67E-001 **R > 1/4 Case 3**	θ = 1.80E-003 m^2/s
Gradient = 0.03	
θ = 1.02E-003 m^2/s	

Case 2

McEnroe	Giroud
R = 2.35E+000 **R > 1/4 Case 3**	θ = 5.00E-001 **m²/s**
Gradient = 0.01	
θ = 4.26E-001 **m²/s**	

Case 3

McEnroe	Giroud
R = 2.35E+000 **R > 1/4 Case 3**	θ = 5.00E-001 **m²/s**
Gradient = 0.01	
θ = 4.26E-001 **m²/s**	

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

References

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Designing with Geosynthetics". **R.M. Koerner**, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.

"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". **J. P. Giroud**, **J. G. Zornberg** and **A. Zhao**, *Geosynthetics International*, Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". **G. N. Richardson**, J.P. Giroud and **A. Zhao**, *Geotechnical Fabrics Report*, March, 2002

"Maximum Saturated depth over Landfill Liners". B. McEnroe, Journal of Environmental Engineering (Vol. 19, No. 2, March/April, 1993).

Pipe Deflection

PIPE PARAMETERS - AASHTO M294, Type S

effective radius (in), R =	3.543
outside diameter (in), D=	*9.45*
thickness (in), t =	*1.310*
unit area of wall (in^2/in), A =	*0.128*
unit moment of inertia (in^4/in), I =	0.007
flexural modulus (psi), E_f =	100,000
ring compression modulus (psi), E_{rc} =	100,000
flexural stiffness (psi), $K_f = 6E_fI/R^3$ =	89
ring compression stiffness (psi), $K_{rc} = E_{rc}A/R$ =	3,613
distance from inner wall to n.a. (in), c =	0.13

SOIL PARAMETERS - good granular soil

mod of soil reaction at 5' of cover (psi), E'_5 =	1000
modulus of soil reaction (psi), E' =	3,572
Poisson's ratio, u =	0.30
constr mod (psi), M*=E*(1-u)/((1+u)(1-2u))=	4808
lateral stress ratio = K = u/(1-u) =	0.429
sym lateral stress ratio = B = (1/2)(1+K) =	0.714
antisym lat stress ratio = C = (1/2)(1-K) =	0.286

SOIL/STRUCTURE PARAMETERS (full slippage)

ring flexibility ratio, UF =(1+K)M*/K_{rc} =	1.90
bending flexibility ratio, VF = (1-K)M*/K_f =	30.9

STRESS FUNCTION COEFFICIENTS

constant term, a_0* =	0.205
cos(2*theta), a_2** =	0.957
sin(2*theta), b_2** =	0.935

LOAD PARAMETERS

unit weight of soil (lb/ft^3) =	75
height of fill above crown (ft) =	300.0
surcharge pressure (psi), P =	156.3

RESPONSE OF PIPE WALL

deg c.c.w. from horiz	radial soil press P_r(psi)	radial defl w(in)	tang defl v(in)	circum wall thrust N(#/in)	wall bend mom(M) (#-lb/in)	ring comp stress (psi)	inner bend stress (psi)	outer bend stress (psi)	total stress inner (psi)	total stress outer (psi)
0	83.0	-0.066	0.000	321	29	-2510	-558	5148	-3067	2638
10	83.3	-0.057	0.027	321	27	-2507	-529	4887	-3036	2381
20	84.3	-0.030	0.050	320	23	-2497	-448	4136	-2945	1638
30	85.9	0.010	0.067	318	17	-2483	-323	2984	-2806	501
40	87.7	0.060	0.076	316	9	-2466	-170	1571	-2636	-895
50	89.8	0.114	0.076	313	0	-2447	-7	68	-2455	-2379
60	91.6	0.164	0.067	311	-8	-2430	146	-1345	-2284	-3775
70	93.2	0.204	0.050	309	-14	-2416	270	-2496	-2145	-4912
80	94.2	0.231	0.027	308	-18	-2407	352	-3248	-2055	-5655
90	94.5	0.240	0.000	308	-20	-2403	380	-3509	-2023	-5912
100	94.2	0.231	-0.027	308	-18	-2407	352	-3248	-2055	-5655
110	93.2	0.204	-0.050	309	-14	-2416	270	-2496	-2145	-4912
120	91.6	0.164	-0.067	311	-8	-2430	146	-1345	-2284	-3775
130	89.8	0.114	-0.076	313	0	-2447	-7	68	-2455	-2379
140	87.7	0.060	-0.076	316	9	-2466	-170	1571	-2636	-895
150	85.9	0.010	-0.067	318	17	-2483	-323	2984	-2806	501
160	84.3	-0.030	-0.050	320	23	-2497	-448	4136	-2945	1638
170	83.3	-0.057	-0.027	321	27	-2507	-529	4887	-3036	2381
180	83.0	-0.066	0.000	321	29	-2510	-558	5148	-3067	2638

CALCULATION OF RING SHORTENING

deg c.c.w. from horiz	ring comp stress (psi)	ring comp strain (in/in)	ring shortening (in)
0	-2510	-0.02509895	-0.0155
10	-2507	-0.0251	-0.0155
20	-2497	-0.02497426	-0.0154
30	-2483	-0.02483247	-0.0154
40	-2466	-0.02465853	-0.0152
50	-2447	-0.02447343	-0.0151
60	-2430	-0.02429949	-0.0150
70	-2416	-0.0241577	-0.0149
80	-2407	-0.02406515	-0.0149
90	-2403	-0.024033	-0.0149
100	-2407	-0.02406515	-0.0149
110	-2416	-0.0241577	-0.0149
120	-2430	-0.02429949	-0.0150
130	-2447	-0.02447343	-0.0151
140	-2466	-0.02465853	-0.0152
150	-2483	-0.02483247	-0.0154
160	-2497	-0.02497426	-0.0154
170	-2507	-0.0251	-0.0155
180	-2510	-0.02509895	-0.0155
		SUM (l/2 circle) =	-0.2890

COMMENTS

1. This is 8" diameter ADS Type C

2. Flexural and compressive modulus are taken as 100,000 psi (HDPE typical).

3. Typical E'_5 values (in psi) for various soils are listed in the table below:

Type of soil	Standard AASHTO Relative Compaction 85%	90%	95%
Fine-grained soils with less than 25% sand (CL, ML, DL-ML)	500	700	1000
Coarse-grained soils with fines (SM, SC)	600	1000	1200
Coarse-grained soils with little or no fines (SP, SW, GP, GW)	700	1000	1600

MISC CALCS

Vertical deflection (%) =	6.78
Horizontal deflection (%) =	-3.74
Critical Buckling Pressure (psi), P_{cr}=	226.4
Radial Soil Pressure at Crown (psi), P_{act}=	94.5
Arc length of each sector (in) =	0.6184

CIRCUMFERENCE SHORTENS= -0.58 inches

Calculations by: DMW
Geotechnical Engineer

ATTACHMENT 3
ALTERNATIVE FILL PLAN STABILITY EVALUATION

ALTERNATIVE FILL PLAN STABILITY EVALUATION
of the
WASATCH REGIONAL LANDFILL
Tooele County, Utah

Prepared for:

ALLIED WASTE INDUSTIRES, INC
111 West Highway 123
East Carbon, Utah

Prepared by:

VECTOR ENGINEERING, INC.
An Ausenco group company

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Grass Valley, CA 95945
(530) 272-2448

Project No. 061204.11
February 2009

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this analysis was to evaluate the slope stability for alternative liner systems and final fill configurations without benches for the Wasatch Regional Landfill (WRL). Stability analyses were conducted on several landfill configurations to evaluate the stability of the landfill with benches constructed in the final cover rather than benched into the waste.

1.2 Scope of Work

Vector's scope of work included the evaluation of the final liner system options and alternative waste fill configurations for the WRL. Slope stability analyses were performed to ensure the static and pseudo-static stability of the system, and included the following critical design elements:

1. A maximum overall waste slope of 4 horizontal to 1 vertical (4H:1V) *without* benches, with a top deck slope of approximately 5%.
2. Side slopes lined with textured geomembrane and high-strength geosynthetic clay liner (GCL).
3. A floor-liner system comprised of GCL, either smooth or textured geomembrane, and a geocomposite.

The work tasks performed for this study included the following:

1. *Slope Stability Analyses.* Limit-equilibrium slope stability analyses were performed for an idealized cross section of the landfill with no benches in the waste. Slope stability was evaluated for static and pseudo-static (earthquake) conditions.
2. *Displacement Analyses.* Based on the results of the pseudo-static stability analyses, potential displacements were estimated for the design earthquake magnitude.
3. *Report Preparation.* This report summarizes the results and conclusions for each of the tasks listed above.

1.3 Location and General Description

The WRL is located at 8833 North Rowley Road, North Skull Valley, Utah; west of the Great Salt Lake and adjacent to the east side of the Lakeside Mountain Range in Tooele County. The WRL will consist of eleven phases covering approximately 793 acres and will have an ultimate capacity of approximately 160 million cubic yards.

In the final configuration, the waste slopes will be graded at a maximum slope of 4H:1V, with a top deck slope of approximately 5 percent. This evaluation investigates the stability at shallower slopes (i.e. 4.5H:1V and 5.65H:1V) and without benches in the waste material. The highest slope is located on the east side of the landfill running in a north-south direction, having a vertical slope height of approximately 200 ft.

The side-slope liner system and floor liner system configurations used in this stability evaluation are discussed in the *Waste Fill Stability Evaluation of the Wasatch Regional Landfill, Tooele County, Utah* (Vector, 2009) report. Our evaluation considers two floor liner systems configurations, one with a smooth HDPE geomembrane, like the system currently installed at WRL, and one configuration utilizing textured HDPE geomembrane for improved stability.

2.0 SUBSURFACE INVESTIGATION AND CONDITIONS

2.1 Field Investigation

Previous geotechnical investigations for the WRL were conducted by AGEC (2004, 2005) and Kleinfelder (2004). In addition, Vector conducted logging and sampling of four soils from test pits excavated in 2006. Classification tests were performed for the samples, including initial moisture (ASTM D-2216), particle size analysis (ASTM D-422), and Atterberg limits (ASTM D-4318).

2.2 Laboratory Testing

For the purpose of this study, additional laboratory testing was not required. Material shear strength properties were determined from the laboratory testing performed by Vector in April 2008. LSDS tests were completed to obtain shear strength properties for the critical interfaces. Laboratory test results are located in Appendix A of the Vector report *Waste Fill Stability Evaluation of the Wasatch Regional Landfill, Tooele County, Utah* (Vector, 2009).

2.3 Subsurface Conditions

Subsurface information presented within this report was obtained from the Geotechnical Investigation Permit Modification prepared by AGEC (2004) for the WRL. Subsurface conditions at the site were characterized by exploratory borings drilled by AGEC and the subsurface information reported by Kleinfelder and Vector. The subsurface profile generally consists of clay, silt and fine sand on the lower elevation portions of the site, with coarser grained materials present at higher elevations. Limestone bedrock was encountered in boring B-1 (AGEC, Dec. 2004) at a depth of 143 ft.

3.0 FAULTING, SEISMOLOGY & EARTHQUAKE GROUND MOTION

A complete seismic hazard evaluation for WRL was conducted as part of Vector's stability report *Waste Stability Evaluation of the Wasatch Regional Landfill, Tooele County, Utah* (Vector, 2009). Deterministic seismic hazard analyses were conducted for 12 fault sources within a 160 km radius of the WRL to provide the potential ground motion seismic evaluation of the waste fill stability.

3.1 Design Basis Earthquake Event

As determined from the seismic hazard evaluation, the site historically experienced an estimated acceleration of 0.10 g during the event of March 12, 1934, which was the most critical for the site. Based on the risks associated with the Stansbury Fault, a site acceleration of 0.436 g is considered possible. From the probabilistic evaluation, a peak horizontal ground acceleration of 0.435 g was estimated for a 2% probability of exceedance in a 50 year exposure period.

Seed (1979) suggested that to ensure that displacements will be acceptably small, it is only necessary to perform a pseudo-static screening analysis for a seismic coefficient of 0.1 g for earthquakes up to a magnitude 6.5 or 0.15 g for earthquakes up to a magnitude 8.5, and obtain a factor of safety of 1.15 or greater. This procedure is only acceptable for site soils that are not vulnerable to excessive strength loss or pore pressure development. Both field and laboratory experience indicate that clayey soils, dry sands and in some cases dense saturated sands will not lose substantial resistance to deformation as a result of earthquake loading (Seed, 1979).

Based on Vector's seismic hazard analyses (Vector, 2009) and on Seed's (1979) procedure, the design earthquake we have chosen for this site would be from a magnitude 6.9 event on the Stansbury fault. Therefore, a site horizontal seismic coefficient, k_h, of 0.15g was chosen, based on Seed (1979), to be used as a pseudo-static screening value.

4.0 STABILITY ANALYSIS

4.1 General

Vector conducted stability analyses for the WRL for both static and pseudo-static conditions. Pseudo-static analyses were performed to determine the pseudo-static screening factor of safety and the yield acceleration for the slope condition analyzed. Failure surfaces through the waste and along the geomembrane liner were evaluated to determine the factor of safety for slope stability. The cross-section analyzed is located in the northern portion of the WRL and represents the most critical slope of the landfill. The analyzed cross section is presented in Appendix A.

The computer program SLIDE 5, developed by Rocscience, Inc (2003), was used for the analyses to determine the factors of safety and probabilities of failure. Spencer's Method of slices was used in the analysis to obtain the factor of safety. The factor of safety can be defined generally as the resisting forces divided by the driving forces. A factor of safety of 1.0 or less indicates that the slope is potentially unstable. Several search routines were used to evaluate tens of thousands of potential failure surfaces for each case analyzed.

Both static and pseudo-static analyses were performed for circular and non-circular surfaces. The pseudo-static analyses subject the two-dimensional sliding mass to a horizontal acceleration equal to a horizontal earthquake coefficient, k_h, multiplied by the acceleration of gravity. As described in section 4.1, a k_h of 0.15 was used as in our pseudo-static analyses and required a pseudo-static factor of safety of 1.15.

4.2 Material Properties

The material properties of the various components of the landfill needed to perform static and pseudo-static slope stability analyses (e.g. unit weight and shear strength parameters) were obtained from Vector's stability report *Waste Fill Stability*

Evaluation of the Wasatch Regional Landfill, Tooele County, Utah (Vector, 2009). Table 1 shows a summary of the average material properties used for the analyses.

TABLE 1
SUMMARY OF AVERAGE MATERIAL PROPERTIES USED IN STABILITY ANALYSES

SLOPE LINER SYSTEM	ANALYZED CRITICAL INTERFACE	TOTAL UNIT WEIGHT (PCF)	COHESION (PSF)	INTERNAL ANGLE OF FRICTION (DEGREES)
	Compacted Fill (Subgrade)	120	40	31
	Municipal Solid Waste (MSW)	65	100	30
Side Slope Liner GCL vs. Double Textured HDPE Geomembrane	Textured HDPE Geomembrane/ GCL	100	226[A]	14[A]
Floor Liner - Option 1 GCL vs. Double Smooth HDPE Geomembrane vs. Single Sided Geocomposite	Smooth HDPE Geomembrane/ Single Sided Geocomposite	100	20[A]	12[A]
Floor Liner – Option 2 GCL vs. Double Textured HDPE Geomembrane vs. Single Sided Geocomposite	Textured HDPE Geomembrane / Single Sided Geocomposite	100	60[A]	15[A]

A – From statistical analysis based on typical laboratory test results from similar liner interfaces.

4.3 Results of the Stability Analyses

Circular and non-circular surfaces along the waste and liner interface, respectively, were evaluated using Spencer's method to calculate the FOS. The results of the stability analyses are summarized in Table 2. The critical failure surfaces originated near the toe of the waste slopes and day-lighted near the crest. The output presents the material properties, and locations of the critical shear surfaces with the lowest factor of safety (see Appendix A). The minimum factor of safety calculated in the pseudo-static analyses for the two liner system options was 0.89. Based on these results, seismic displacement analyses were performed.

The yield acceleration (k_y) of the landfill mass was calculated for both liner system configurations. The yield acceleration is defined as the horizontal acceleration that, when applied to the slope in the limit equilibrium (seismic) analyses, results in a pseudo-static factor of safety equal to one. The yield acceleration was determined using the Spencer method and the results are shown in Table 2. The output files from SLIDE 5 for these analyses are included in Appendix A.

TABLE 2
SUMMARY OF SLOPE STABILITY RESULTS FOR ALTERNATIVE LINER SYSTEMS AND WASTE FILL CONFIGURATIONS – NO BENCHES

FLOOR LINER SYSTEM	SLOPE H:V	FACTOR OF SAFETY (NON-CIRCULAR)		FACTOR OF SAFETY (CIRCULAR)		YIELD ACCEL	DISPLACEMENT	
		STATIC	SEISMIC	STATIC	SEISMIC	(G)	IN.	ACCEPTABLE?
With Smooth Geomembrane	4:1	1.58	0.89	2.58	1.56	0.11	0.2	Yes
	4.5:1	1.70	0.91	2.76	1.70	0.122	0.03	Yes
	5.65:1	1.96	0.96	3.34	1.76	0.137	0.0	Yes
With Textured Geomembrane	4:1	1.82	1.05	2.58	1.56	0.165	0.0	Yes

The yield acceleration was used in displacement analyses to estimate the permanent displacement of the landfill that could occur from the design seismic event. The method chosen for these analyses was the "Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills," by Bray et al. (1998). This method uses chart solutions to estimate the displacement for earthquake accelerations which are greater than the yield acceleration.

The design earthquake would have a magnitude of 6.9. Based on the earthquake hazard analyses, the design site acceleration would be from a near field event on the Stansbury Fault zone. This event would result in a peak horizontal ground acceleration (PHGA) of 0.436 g at the site. In theory, the landfill will displace during a seismic event when the site acceleration exceeds the yield acceleration.

The yield acceleration for floor-liner Option 1 (the weaker of the two options) was 0.89 g. The analyses show that base sliding of the landfill during the design earthquake would result in top displacements for both options (1 and 2) would be less than 1 inch. For lined landfills, displacements less than or equal to 12 inches are generally considered acceptable (Kavazanjian 1999).

4.4 Conclusions Regarding Slope Stability

A factor of safety equal to or greater than 1.50 and 1.15 is generally considered acceptable for static conditions and pseudo-static conditions, respectively. Under static conditions the section analyzed showed an acceptable factor of safety for all liner configuration options. However, during an earthquake, displacement is possible since the pseudo-static factor of safety was less than 1.15 in both liner configurations. Therefore, a displacement analysis was performed to determine the potential displacement of the waste mass. The seismic displacement analyses indicate that permanent displacements of the landfill from the design seismic event would be small (less than 1 inch).

5.0 CONCLUSIONS

Vector performed slope stability analyses for the WRL based on the conceptual design of the landfill, preliminary soils data and historical seismicity near the site. Circular and non-circular failure surfaces through the waste and the critical liner interface were evaluated to determine the factor of safety for stability. For static conditions, the results of the stability analyses indicate that the landfill will remain stable for both floor liner configurations (smooth and textured HDPE geomembrane) and for all slope angles considered (4:1, 4.5:1 and 5.65:1) without benches in the waste material. For the pseudo-static conditions, the factor of safety for slope stability drops below 1.15, and therefore, a displacement analysis was performed. The displacement estimated from the seismic analysis for the weaker liner condition (smooth geomembrane) ranged from 0.0 in. to 0.2 in., which is considered acceptable (Kavazanjian 1999).

6.0 LIMITATIONS

The recommendations presented in this report are based upon understanding of the project, a field investigation, and the information provided by WRL. This report was prepared in accordance with generally accepted soils and foundation engineering practices applicable at the time the report was prepared. Vector makes no other warranties, either expressed or implied, as to the professional opinions and conclusions provided.

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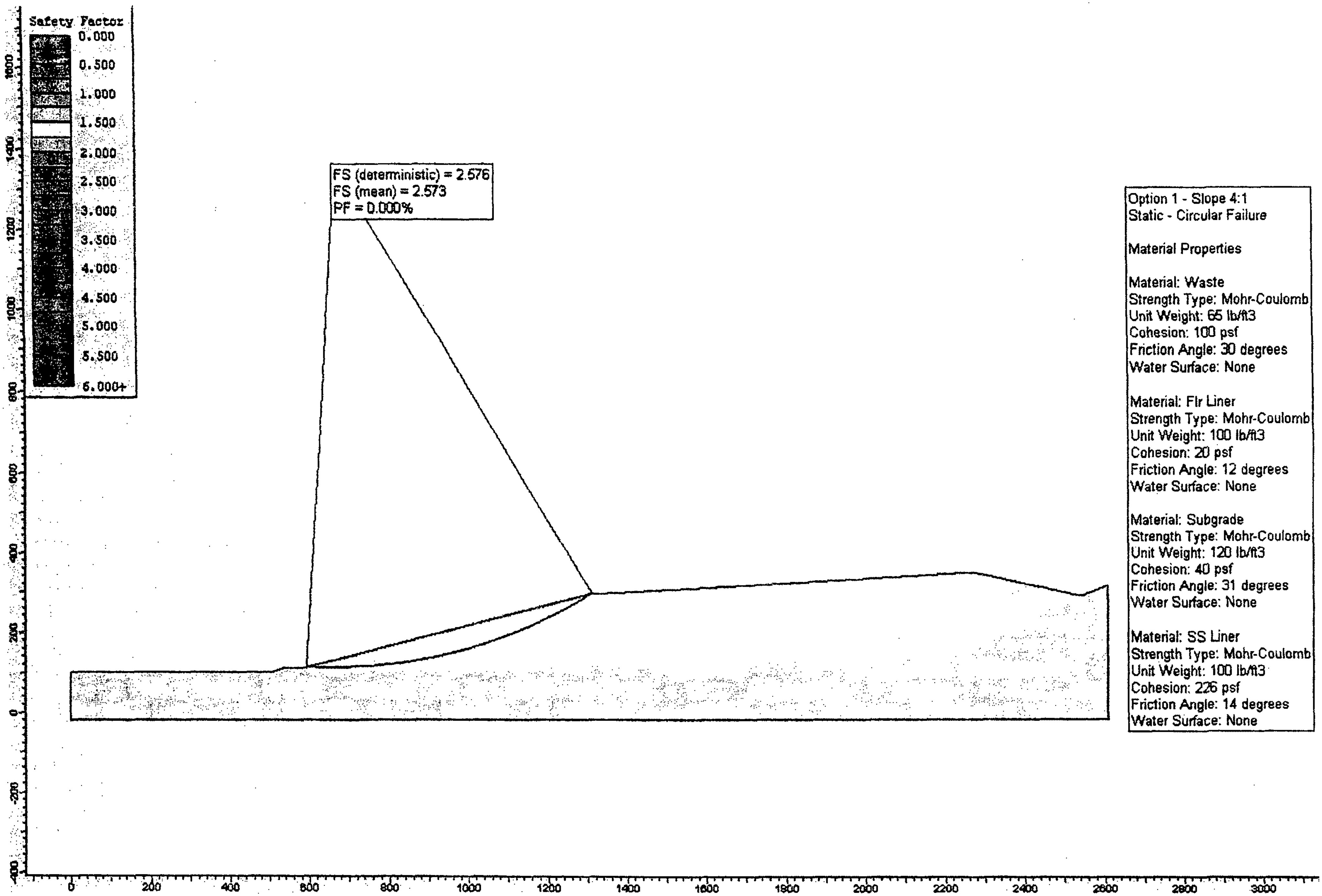
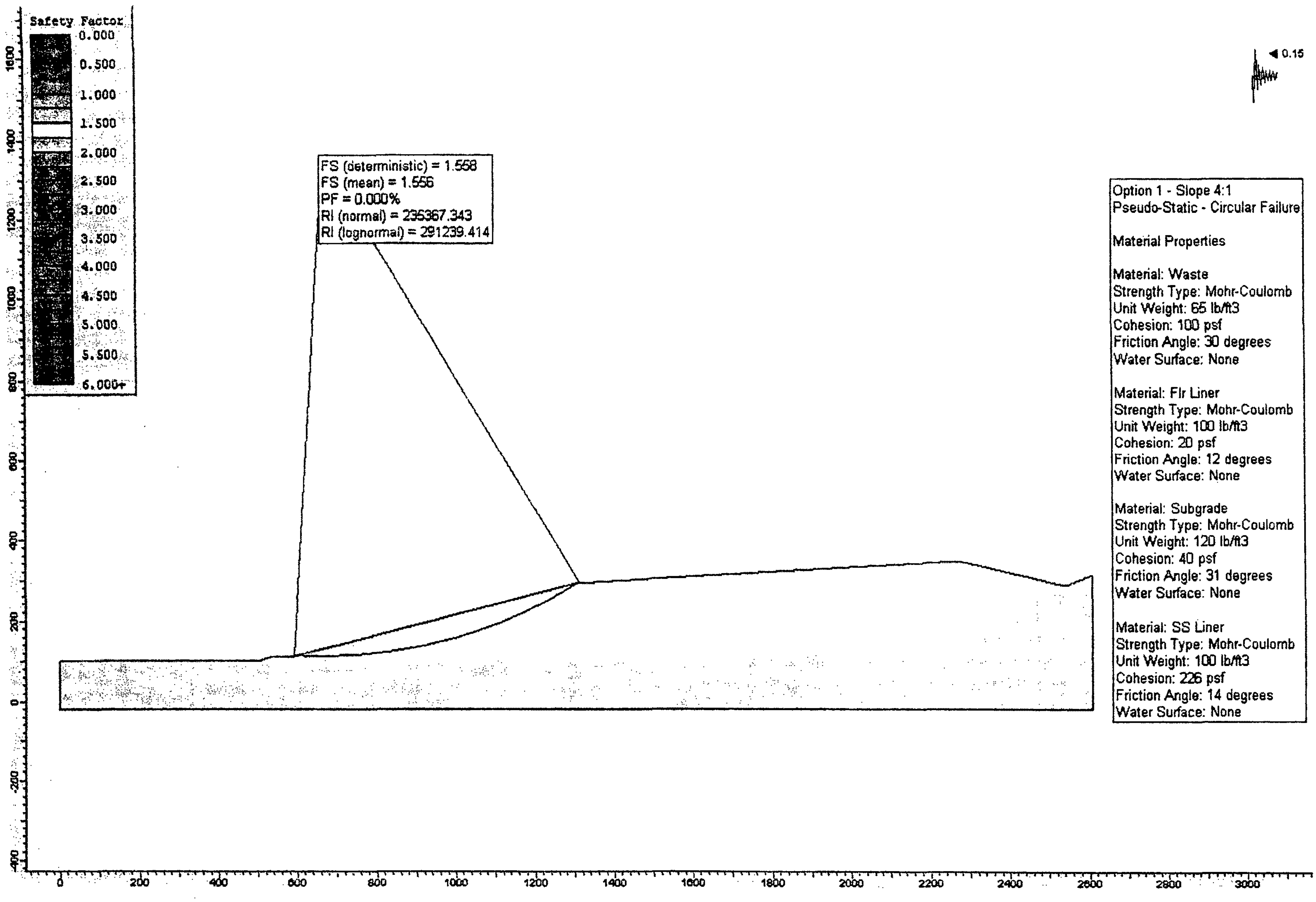
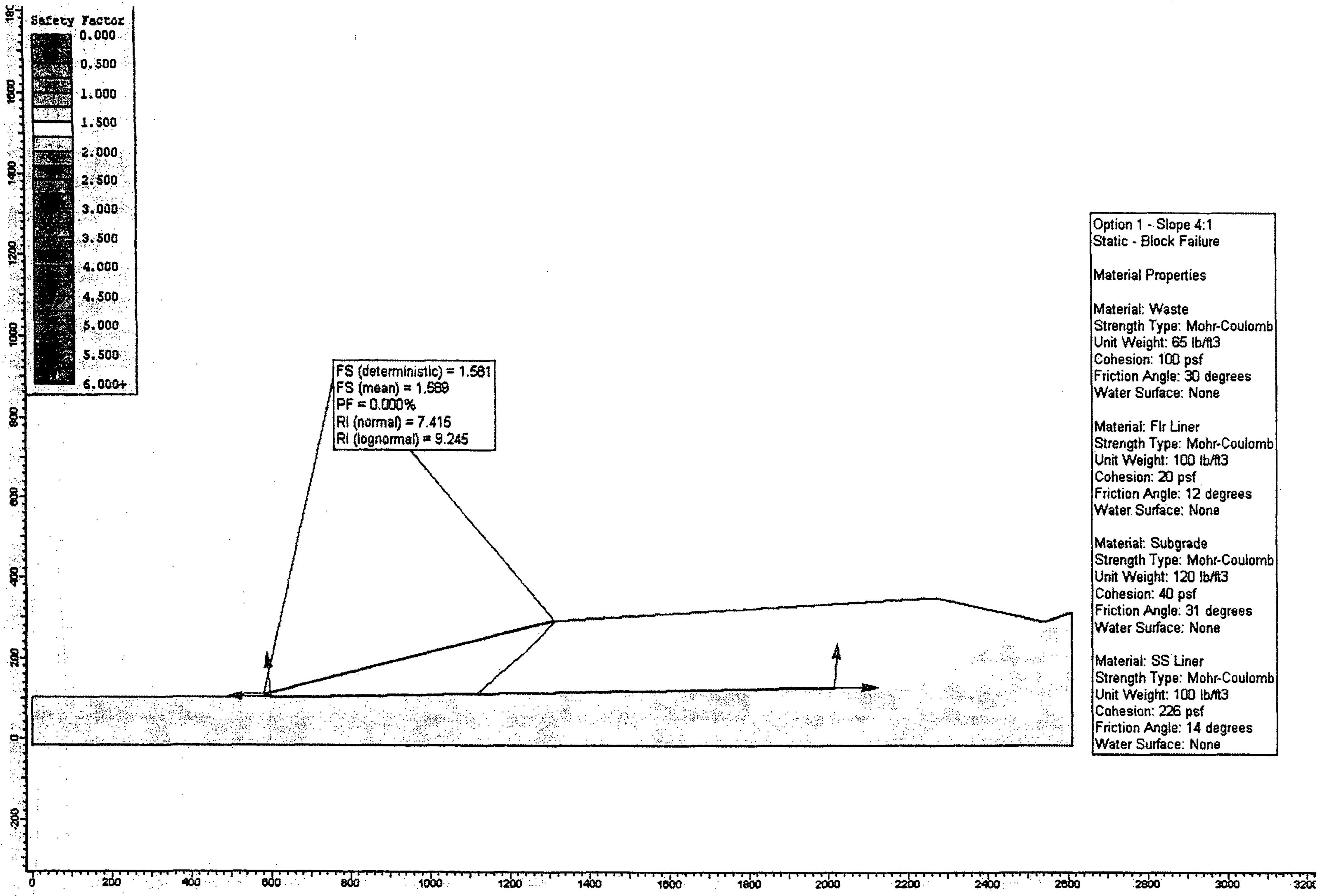
APPENDIX A
SLIDE OUTPUT FILES

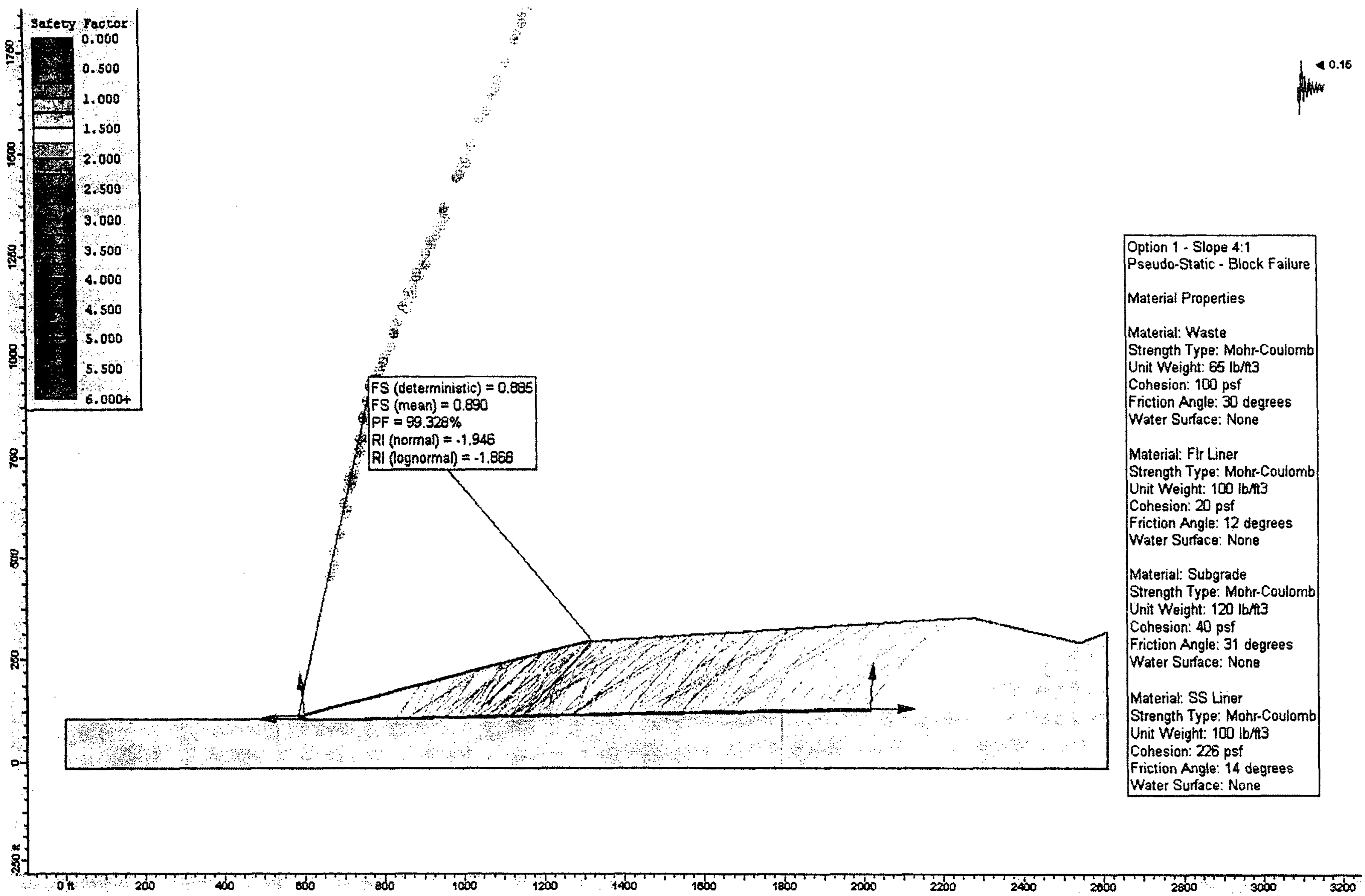


Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 2.576
FS (mean) = 2.573
PF = 0.000%
Option 1 - Slope 4:1
Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None

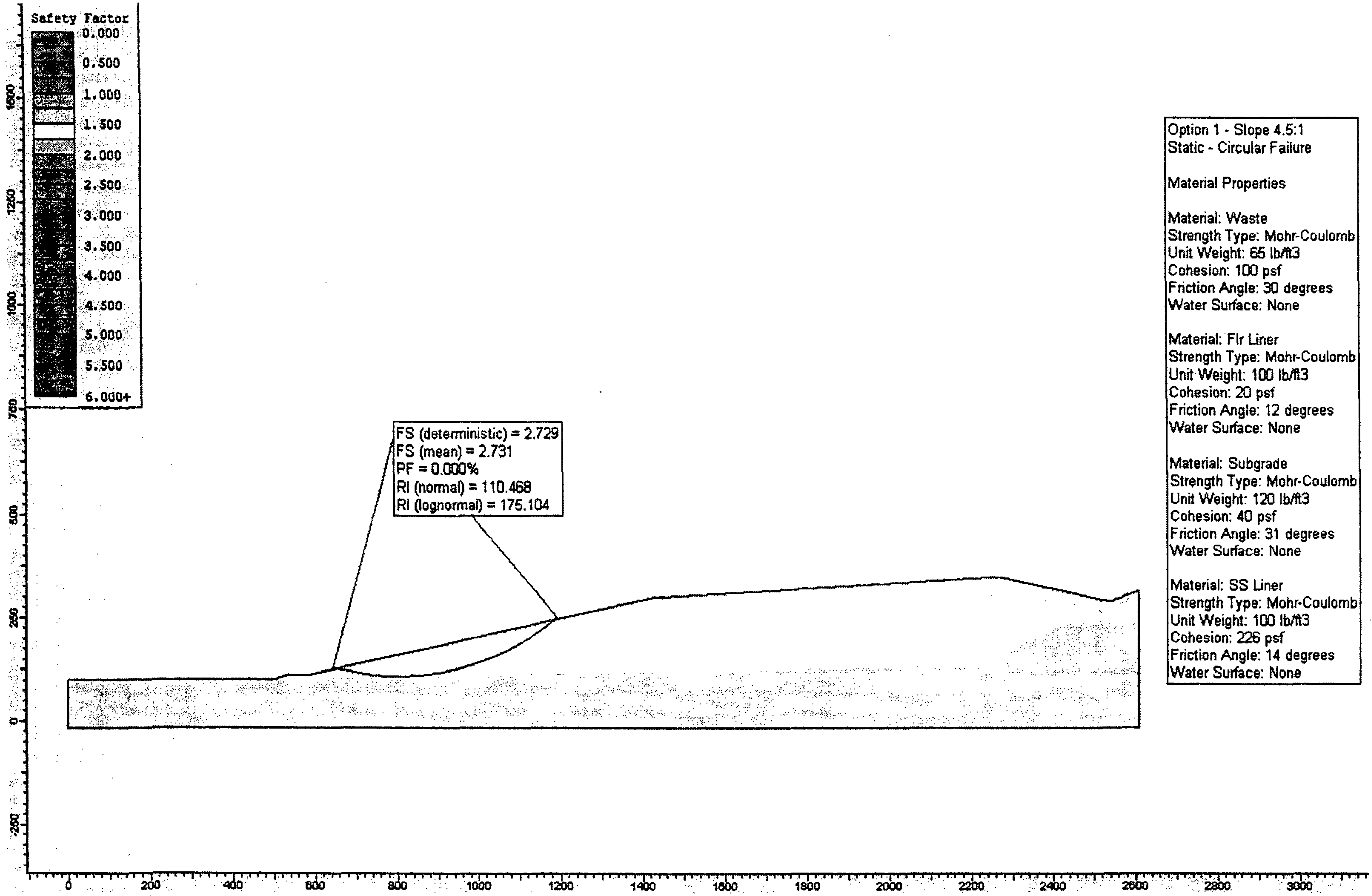

Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.15
FS (deterministic) = 1.558
FS (mean) = 1.556
PF = 0.000%
RI (normal) = 235367.343
RI (lognormal) = 291239.414
Option 1 - Slope 4:1
Pseudo-Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None



Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.581
FS (mean) = 1.589
PF = 0.000%
RI (normal) = 7.415
RI (lognormal) = 9.245
Option 1 - Slope 4:1
Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
-200



Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.15
FS (deterministic) = 0.885
FS (mean) = 0.890
PF = 99.328%
RI (normal) = -1.946
RI (lognormal) = -1.868
Option 1 - Slope 4:1
Pseudo-Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None



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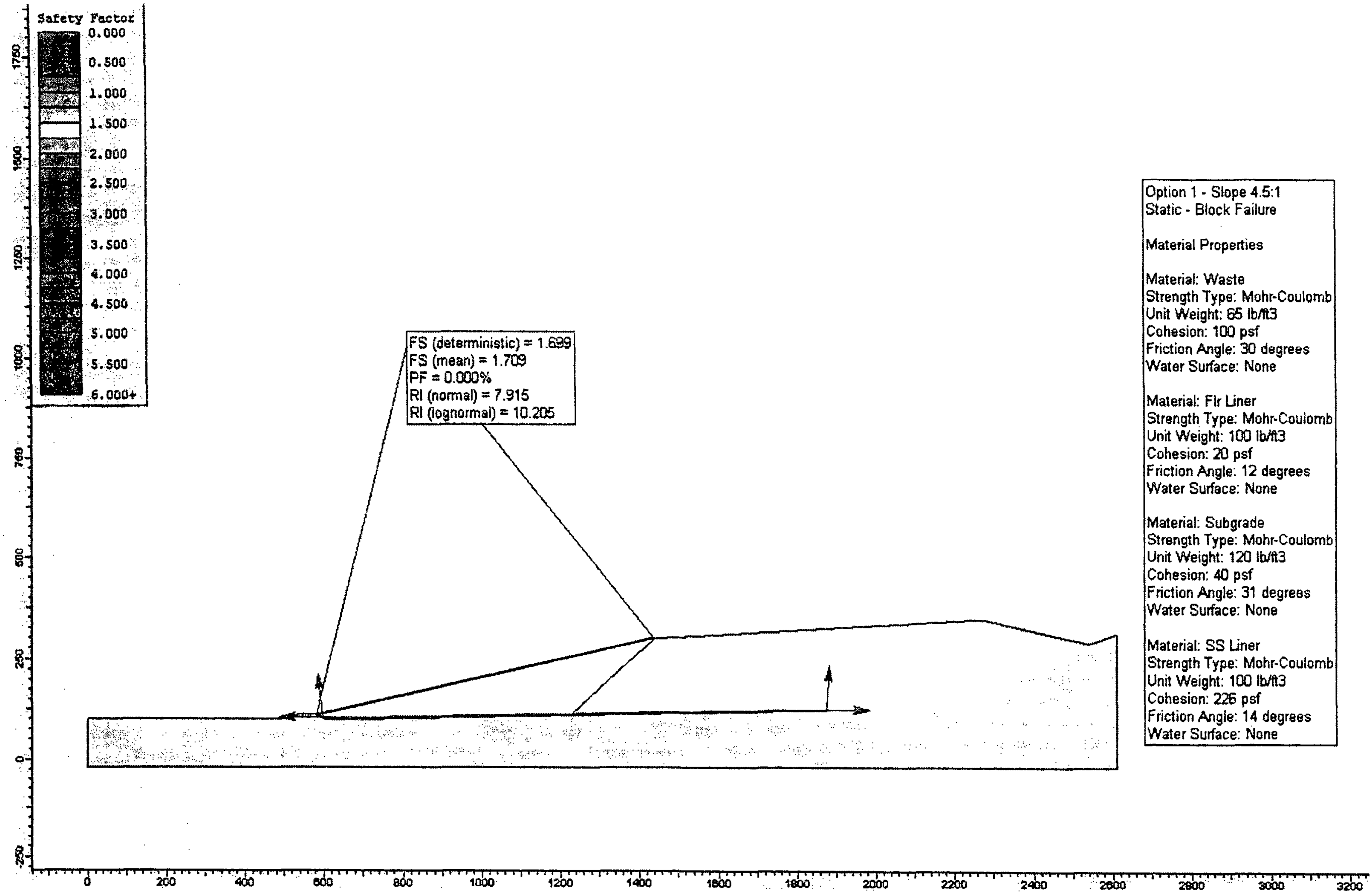
5.500
6.000+
FS (deterministic) = 2.729
FS (mean) = 2.731
PF = 0.000%
RI (normal) = 110.468
RI (lognormal) = 175.104
Option 1 - Slope 4.5:1
Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None



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3.000
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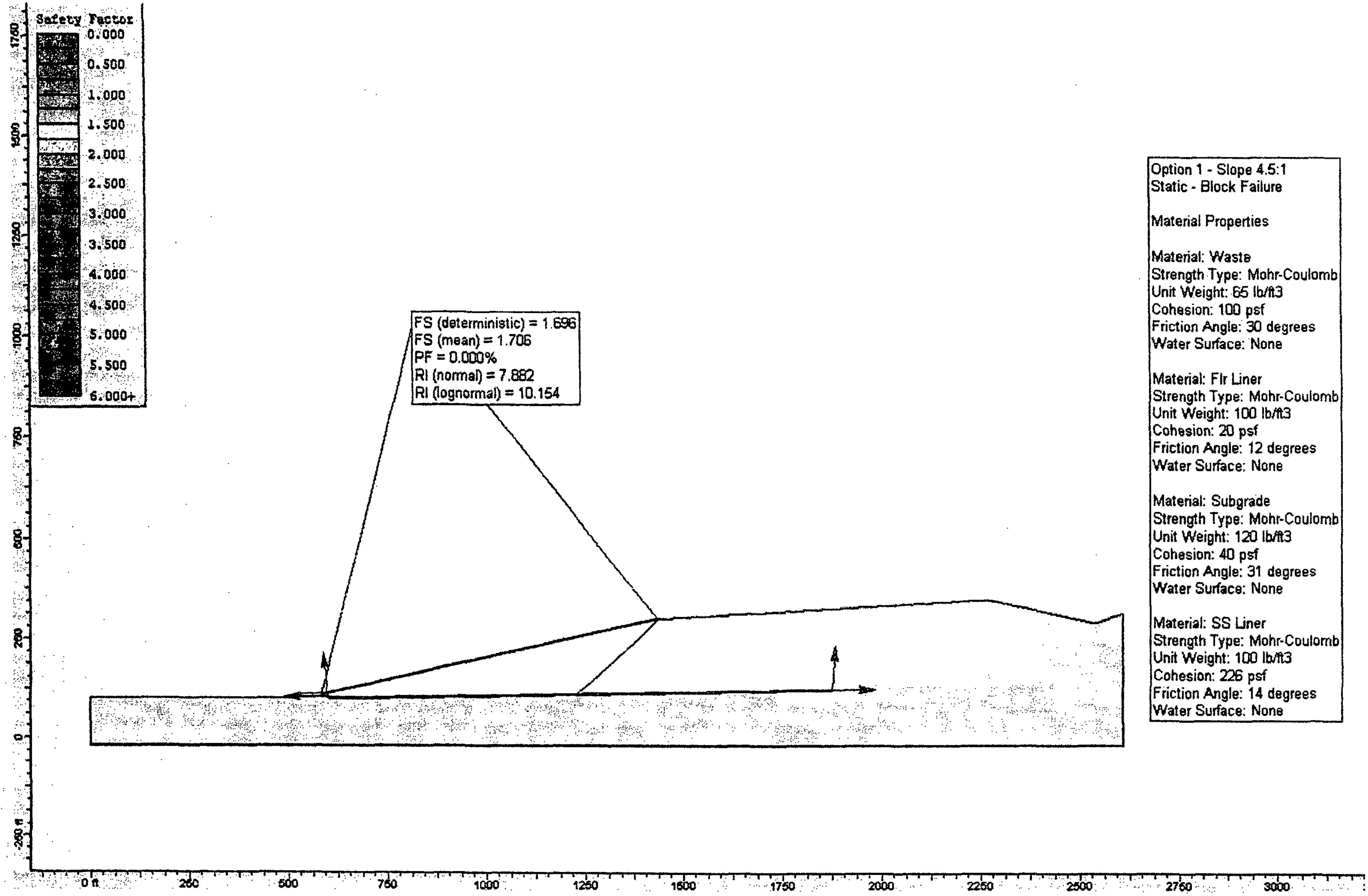
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.699
FS (mean) = 1.709
PF = 0.000%
RI (normal) = 7.915
RI (lognormal) = 10.205
Option 1 - Slope 4.5:1
Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None



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2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.696
FS (mean) = 1.706
PF = 0.000%
RI (normal) = 7.882
RI (lognormal) = 10.154
Option 1 - Slope 4.5:1
Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
0 ft
250
500
750
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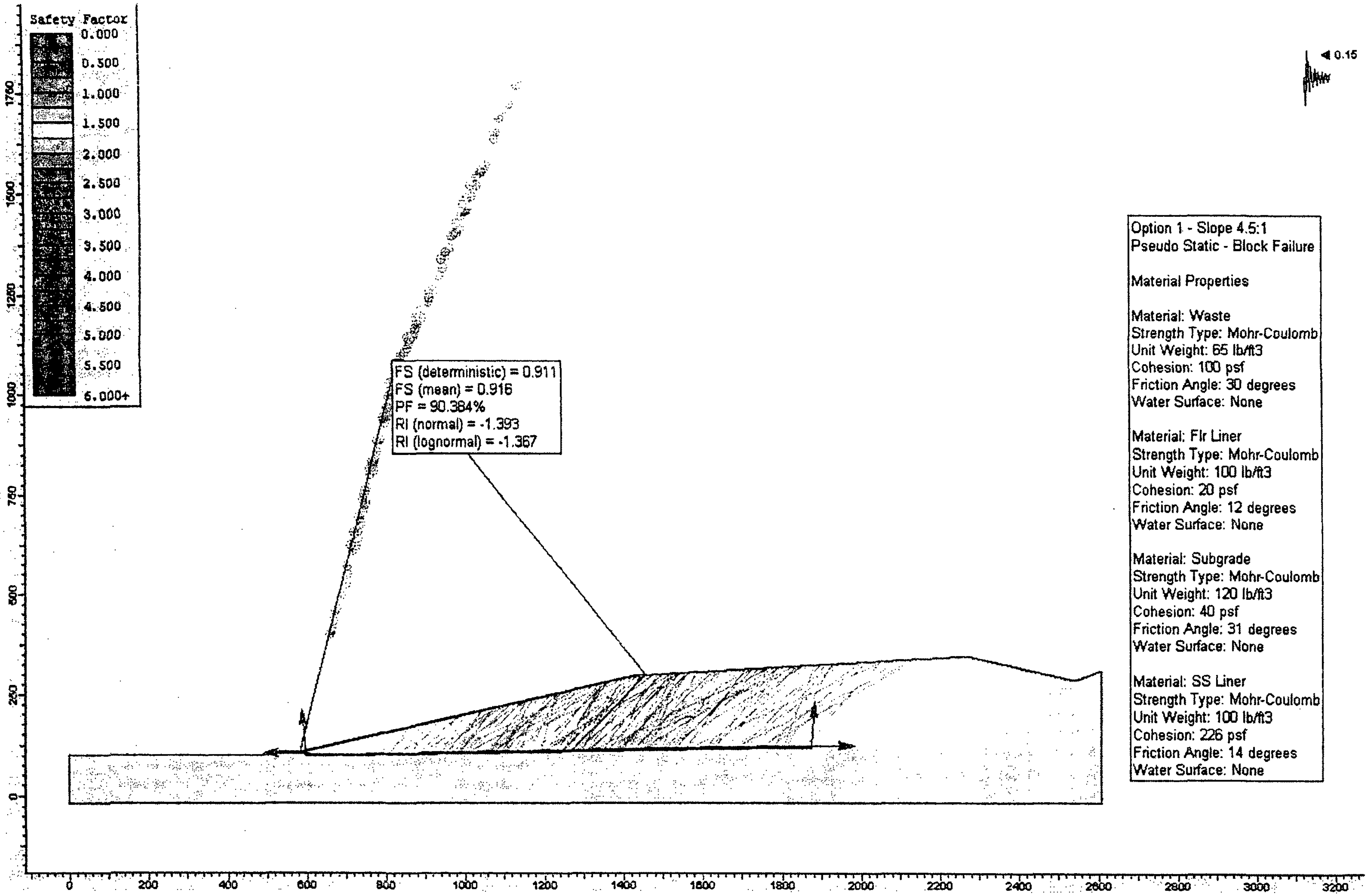
2000
2250
2500
2750
3000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2.000
2.500
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4.000
4.500
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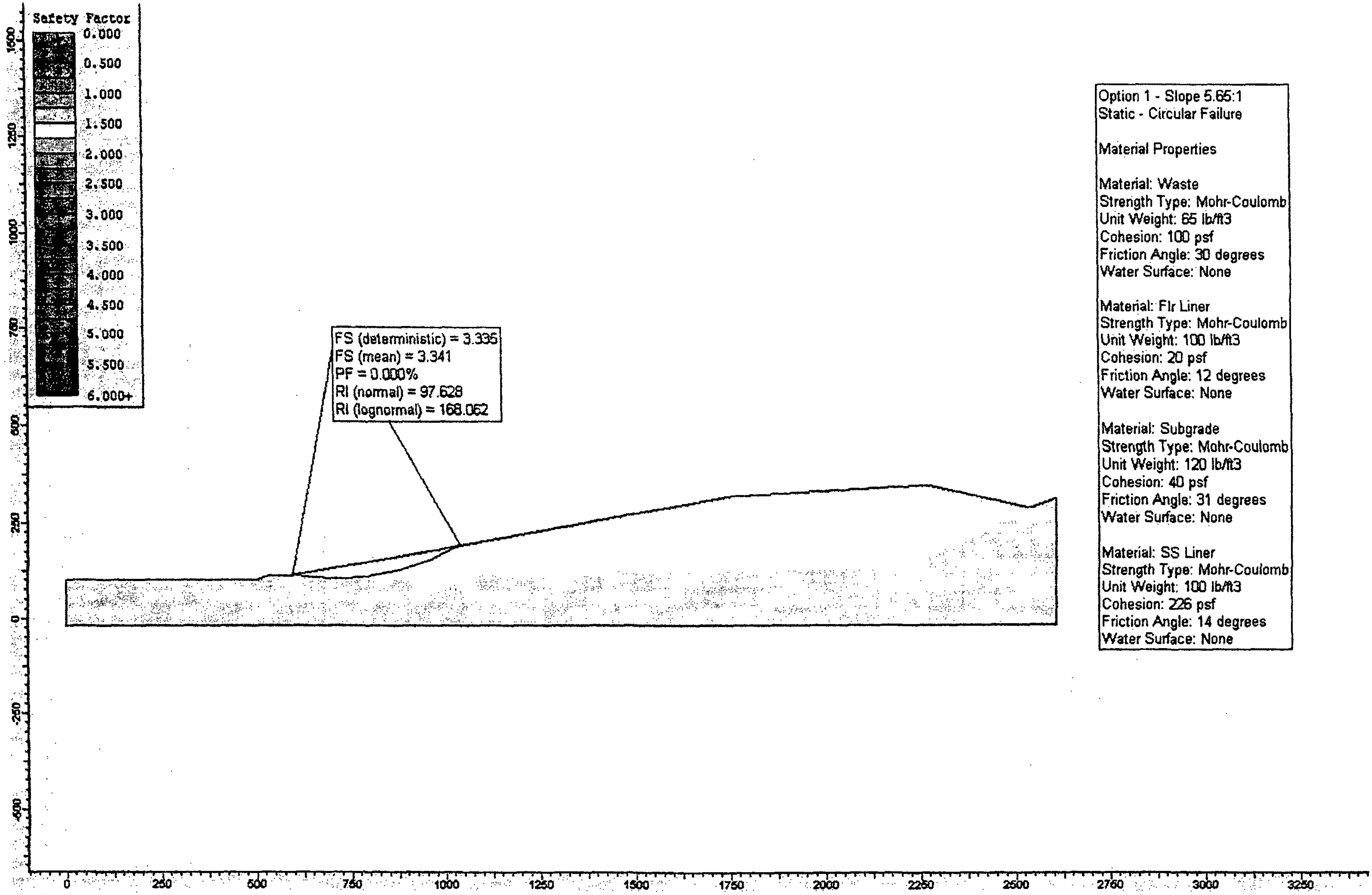
5.500
6.000+
0.15
FS (deterministic) = 0.911
FS (mean) = 0.916
PF = 90.384%
RI (normal) = -1.393
RI (lognormal) = -1.367
Option 1 - Slope 4.5:1
Pseudo Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None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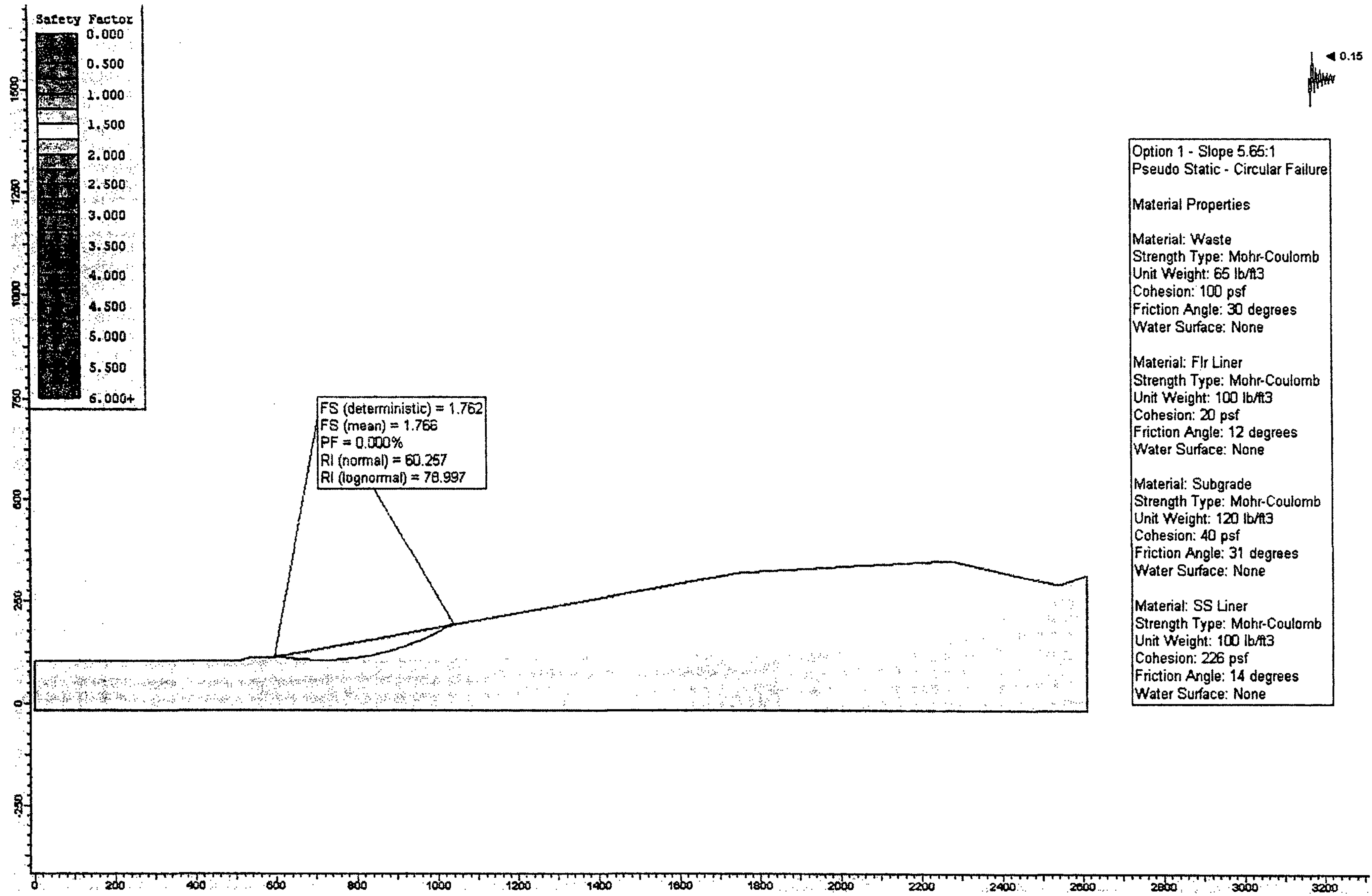
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 3.335
FS (mean) = 3.341
PF = 0.000%
RI (normal) = 97.628
RI (lognormal) = 168.062
Option 1 - Slope 5.65:1
Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250



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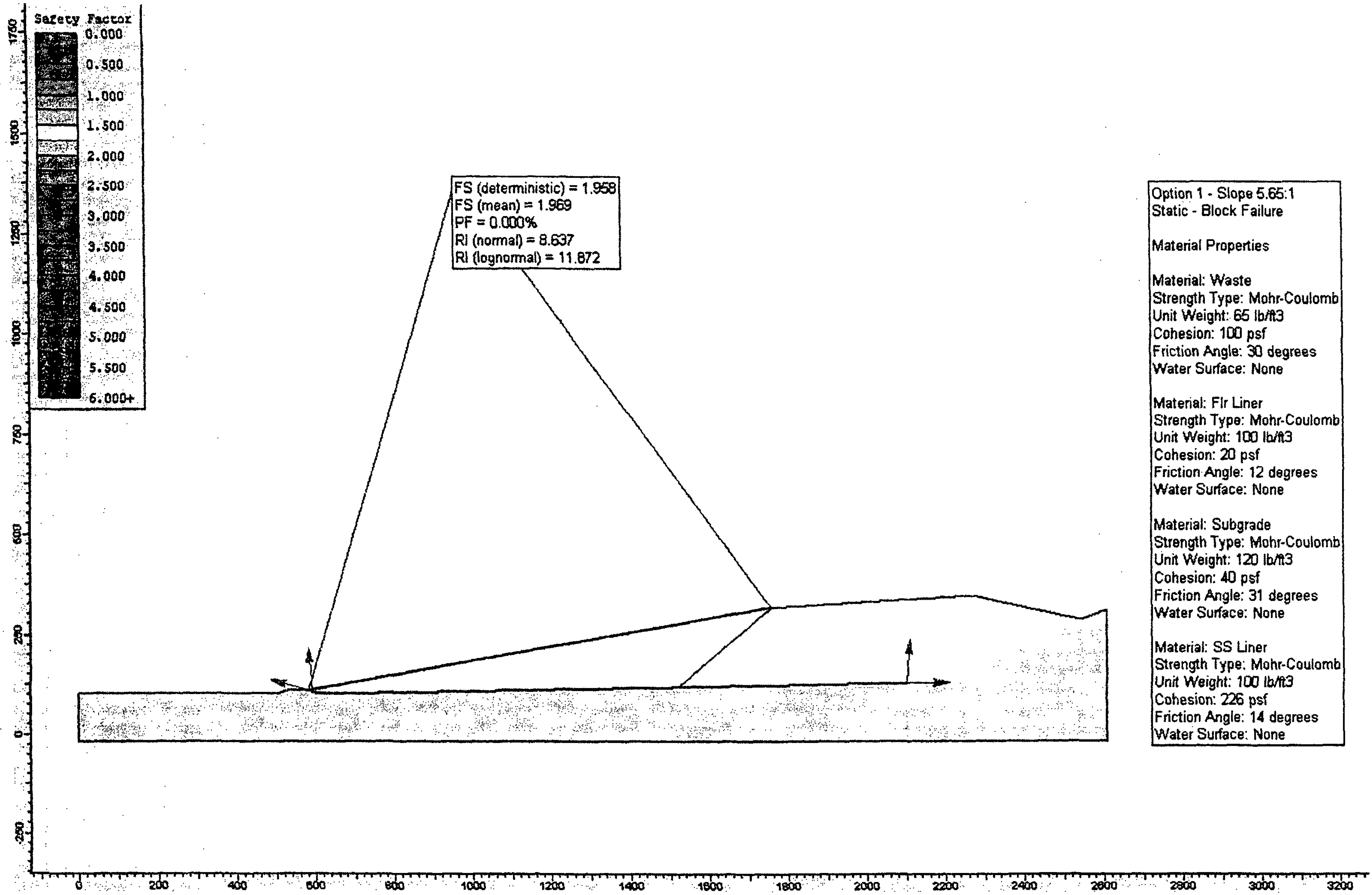
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.15
FS (deterministic) = 1.762
FS (mean) = 1.766
PF = 0.000%
RI (normal) = 60.257
RI (lognormal) = 78.997
Option 1 - Slope 5.65:1
Pseudo Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None



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1.000
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2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.958
FS (mean) = 1.969
PF = 0.000%
RI (normal) = 8.637
RI (lognormal) = 11.872
Option 1 - Slope 5.65:1
Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
1750
1500
1250
1000
750
500
250
0
-250
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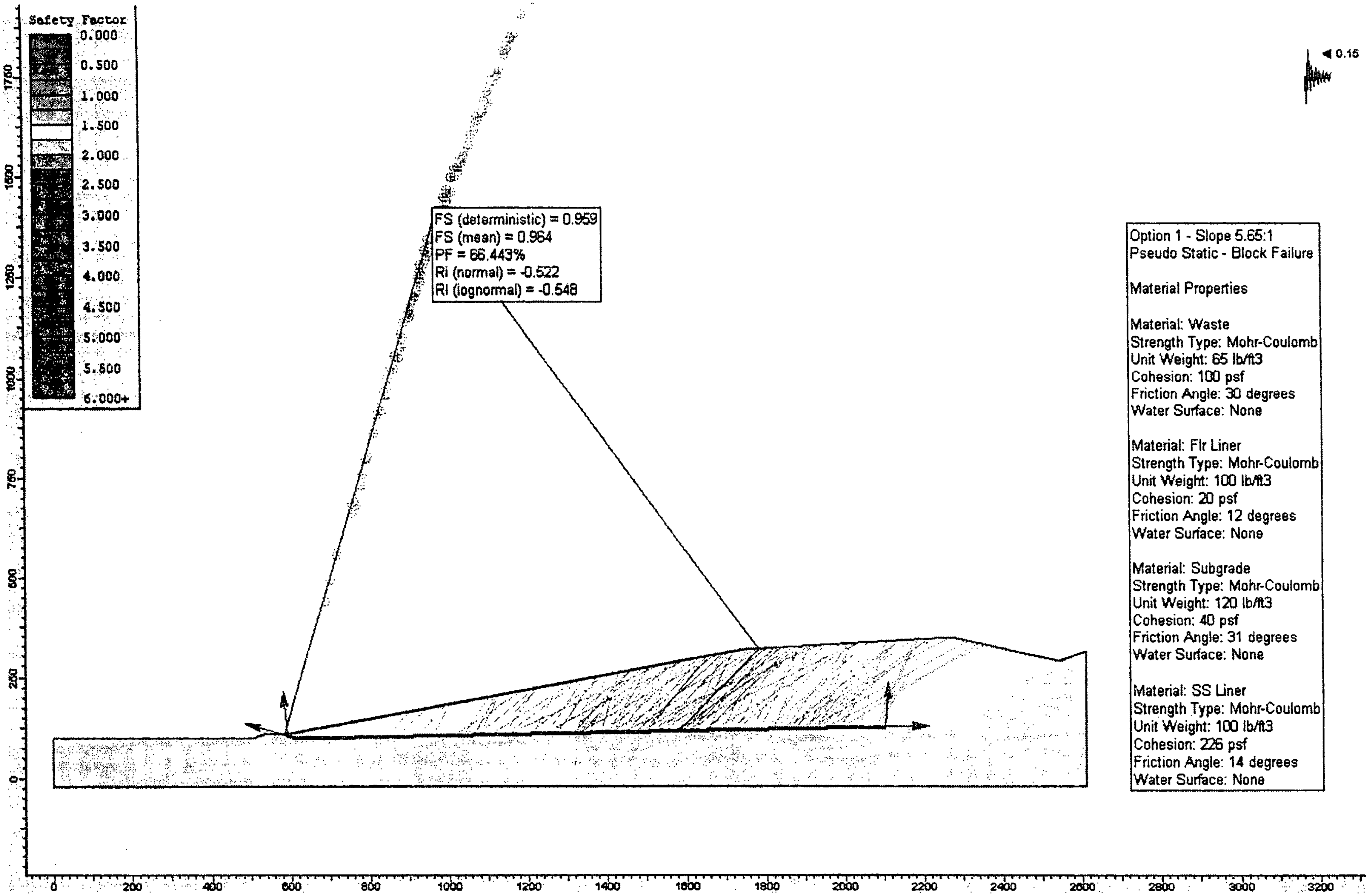
2600
2800
3000
3200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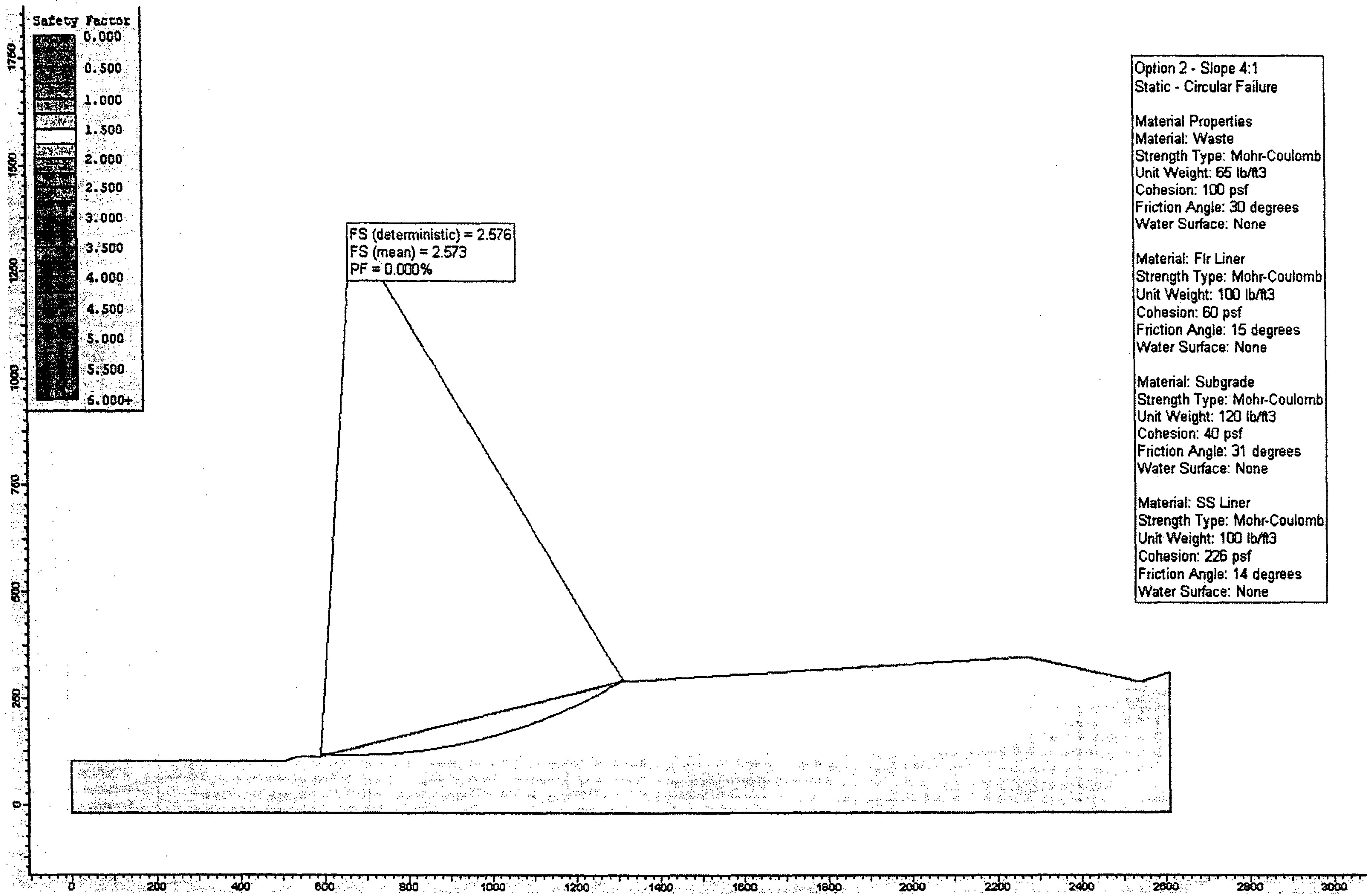
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 0.959
FS (mean) = 0.964
PF = 66.443%
RI (normal) = -0.522
RI (lognormal) = -0.548
0.15
Option 1 - Slope 5.65:1
Pseudo Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 20 psf
Friction Angle: 12 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
1750
1500
1250
1000
750
500
250
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200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1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 2.576
FS (mean) = 2.573
PF = 0.000%
Option 2 - Slope 4:1
Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
1750
1500
1250
1000
750
500
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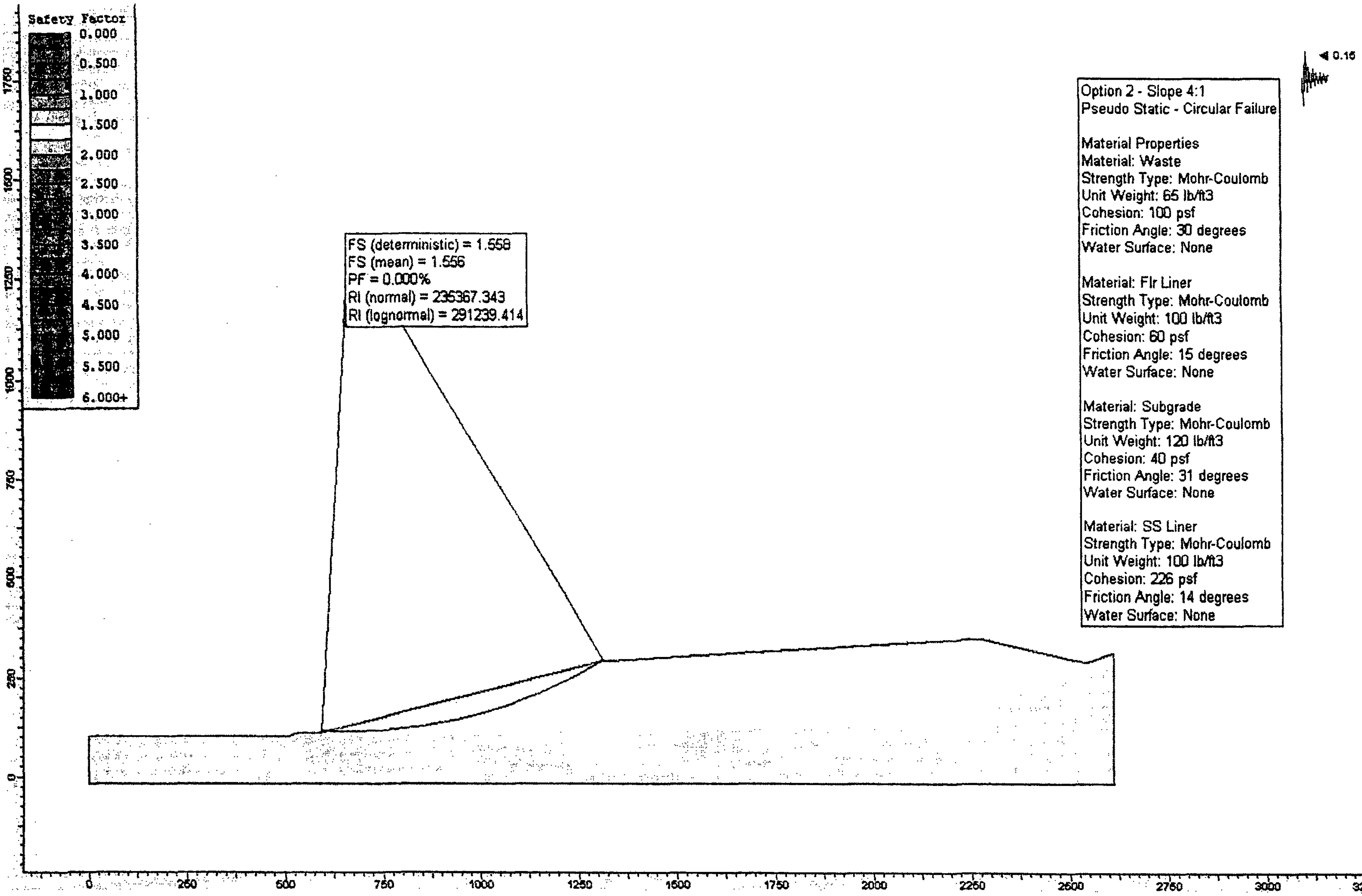
2400
2600
2800
3000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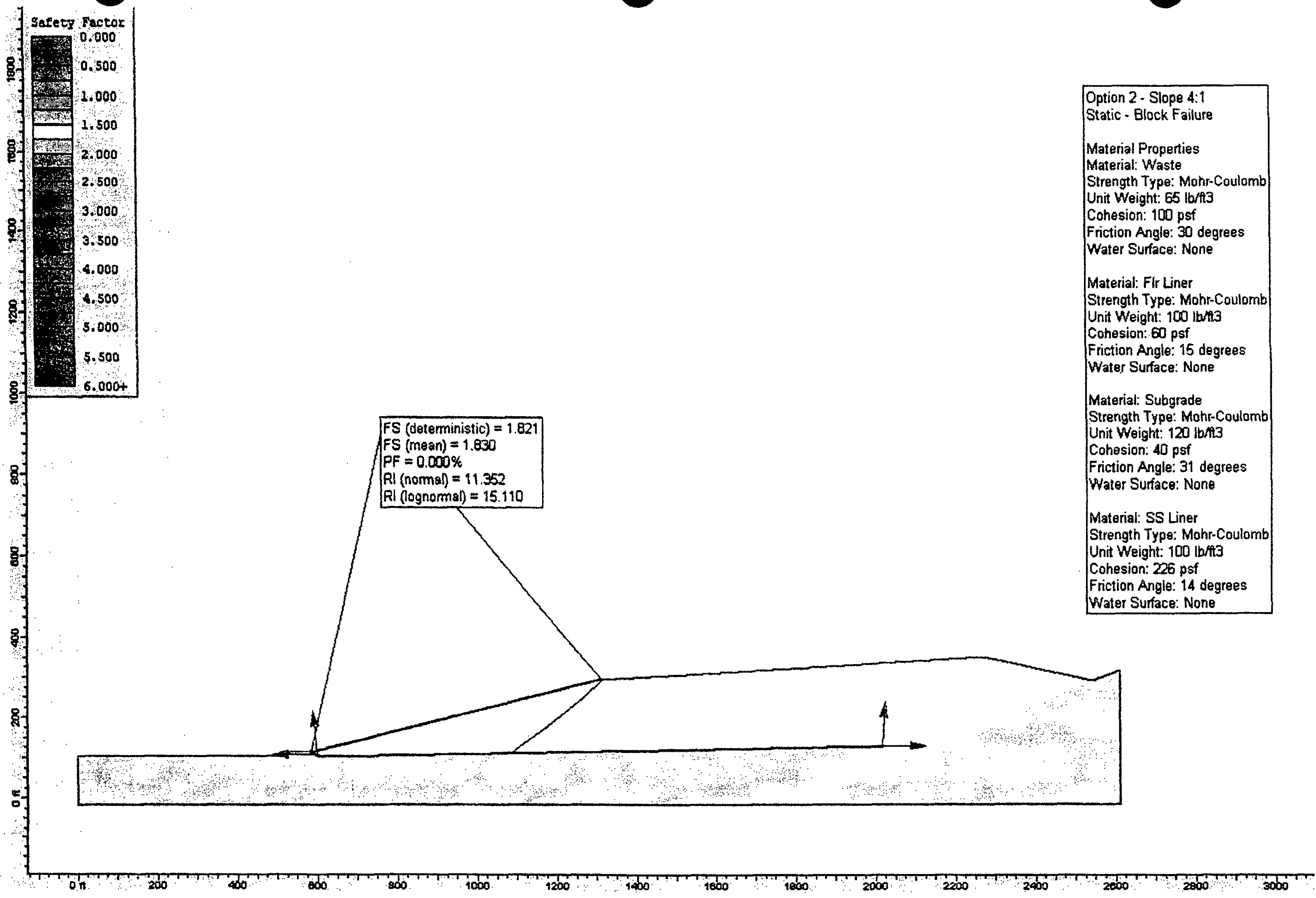
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.558
FS (mean) = 1.556
PF = 0.000%
RI (normal) = 235367.343
RI (lognormal) = 291239.414
Option 2 - Slope 4:1
Pseudo Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
0.15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2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
FS (deterministic) = 1.821
FS (mean) = 1.830
PF = 0.000%
RI (normal) = 11.352
RI (lognormal) = 15.110
Option 2 - Slope 4:1
Static - Block Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
0 ft
200
400
600
800
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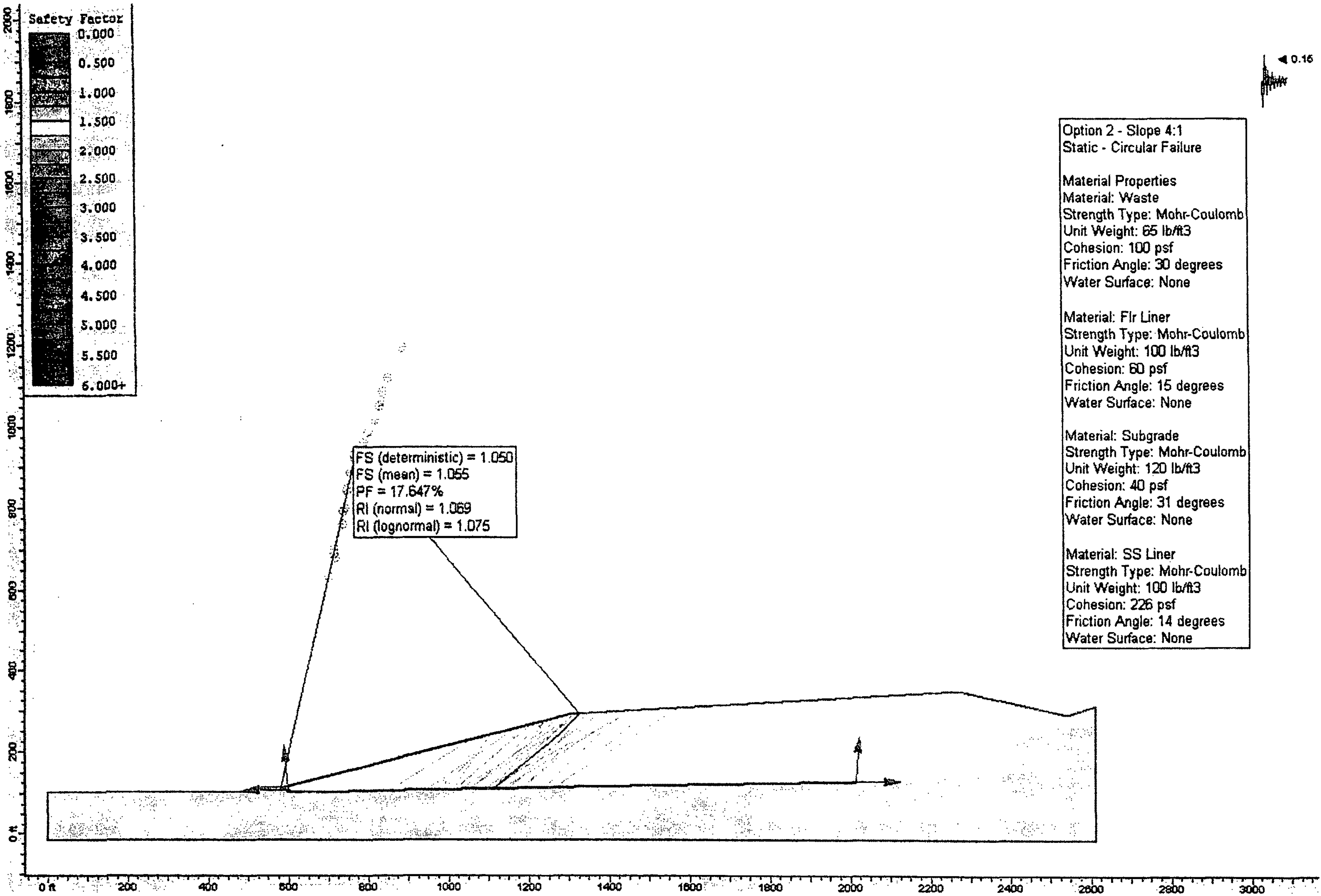
2400
2600
2800
3000



Safety Factor
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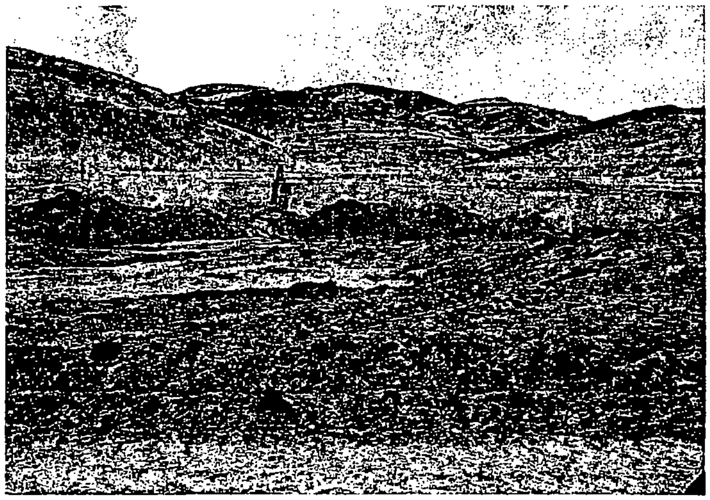
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.16
Option 2 - Slope 4:1
Static - Circular Failure
Material Properties
Material: Waste
Strength Type: Mohr-Coulomb
Unit Weight: 65 lb/ft3
Cohesion: 100 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Flr Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 60 psf
Friction Angle: 15 degrees
Water Surface: None
Material: Subgrade
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 40 psf
Friction Angle: 31 degrees
Water Surface: None
Material: SS Liner
Strength Type: Mohr-Coulomb
Unit Weight: 100 lb/ft3
Cohesion: 226 psf
Friction Angle: 14 degrees
Water Surface: None
FS (deterministic) = 1.050
FS (mean) = 1.055
PF = 17.647%
RI (normal) = 1.069
RI (lognormal) = 1.075
0 ft
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000

APPENDIX 10
EVAPOTRANSPIRATIVE FINAL COVER (VECTOR)

APPENDIX 10.1
Evapotranspirative (ET) Final Cover Permitting Report for the Wasatch Regional Landfill, Utah

EVAPOTRANSPIRATIVE (ET) FINAL COVER PERMITTING REPORT
for the
WASATCH REGIONAL LANDFILL
Tooele, Utah



Prepared for:

Allied Waste, Inc.
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East Carbon, UT 84520
(435) 888-4418

Prepared by:

VECTOR ENGINEERING, INC.
143E Spring Hill Drive
Grass Valley, CA 95945
(530) 272-2448

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
State of Utah

Project No. 061204.00
June 2006

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1.0 INTRODUCTION

1.1 General

The following report presents the results of Vector Engineering, Inc.'s (Vector's) final cover options study at the Wasatch Regional Landfill (WRL) for Allied Waste, Inc. (Allied). The WRL is located west of Rowley Road in Tooele County, Utah, within Section 32, 33, and 34 of Township 2 North, Range 8 West, and within Sections 3 and 4 of Township 1 North, Range 8 West, Salt Lake Base and Meridian. Allied is proposing the use of an engineered monolithic evapotranspirative (ET) cover as an alternative to the prescriptive low-permeability barrier cover for final closure of the WRL.

This report summarizes the engineering analyses performed in support of permitting an ET cover for closure at the WRL. The analyses included modeling the water balance of four ET cover sections; (1) a 2-foot thick monolithic ET cover, (2) a 2.5-foot thick monolithic ET cover, (3) a 3-foot thick monolithic ET cover, and (4) a 4-foot thick monolithic ET cover. In addition, water balance modeling was performed for the previously proposed geomembrane barrier cover (Hansen, 2004) as well as the prescriptive cover described in Utah State Regulations R315-303-3(4)(a) for comparison purposes. Detailed closure design and analyses will be completed prior to final closure.

1.2 Scope of Work

Vector's scope of work included conducting a borrow soil investigation and performing a final cover options study for closure of the WRL. The borrow investigation consisted of analyzing previous geotechnical reports for the WRL as well as sampling and testing four potential cover soils from the proposed borrow area. In support of the final cover options study, five-year water balance simulations were performed using UNSAT-H (version 3.01) with soil hydraulic properties that were measured from two representative on-site borrow soils. In addition, the performance of the previously proposed geomembrane cover and the prescribed barrier cover were analyzed using the HELP model (version 3.06).

2.0 PROJECT DESCRIPTION

2.1 Equivalency Criteria

Allied is proposing the use of an ET cover versus the prescriptive cover for final closure of the WRL. The WRL's currently approved final cover design consists of a soil-geomembrane cover system (Hansen, 2004). An alternative final cover is permissible under Federal and Utah regulations, R315-303-3 (4)(b), provided equivalent or better performance can be demonstrated with respect to percolation through the cover and wind and water erosion. Based on previous ET cover reports in the State of Utah (SCS Engineers, 2005), the equivalency criteria set forth by the Utah Department of Environmental Quality (UDEQ) is 3 mm/yr of cumulative percolation.

2.2 Site Location and Climate

The WRL is located west of the Great Salt Lake and adjacent to the east side of the Lakeside Mountain Range in Tooele County, Utah. The WRL will consist of eleven phases covering approximately 793 acres and will have an ultimate capacity of approximately 160 million cubic yards.

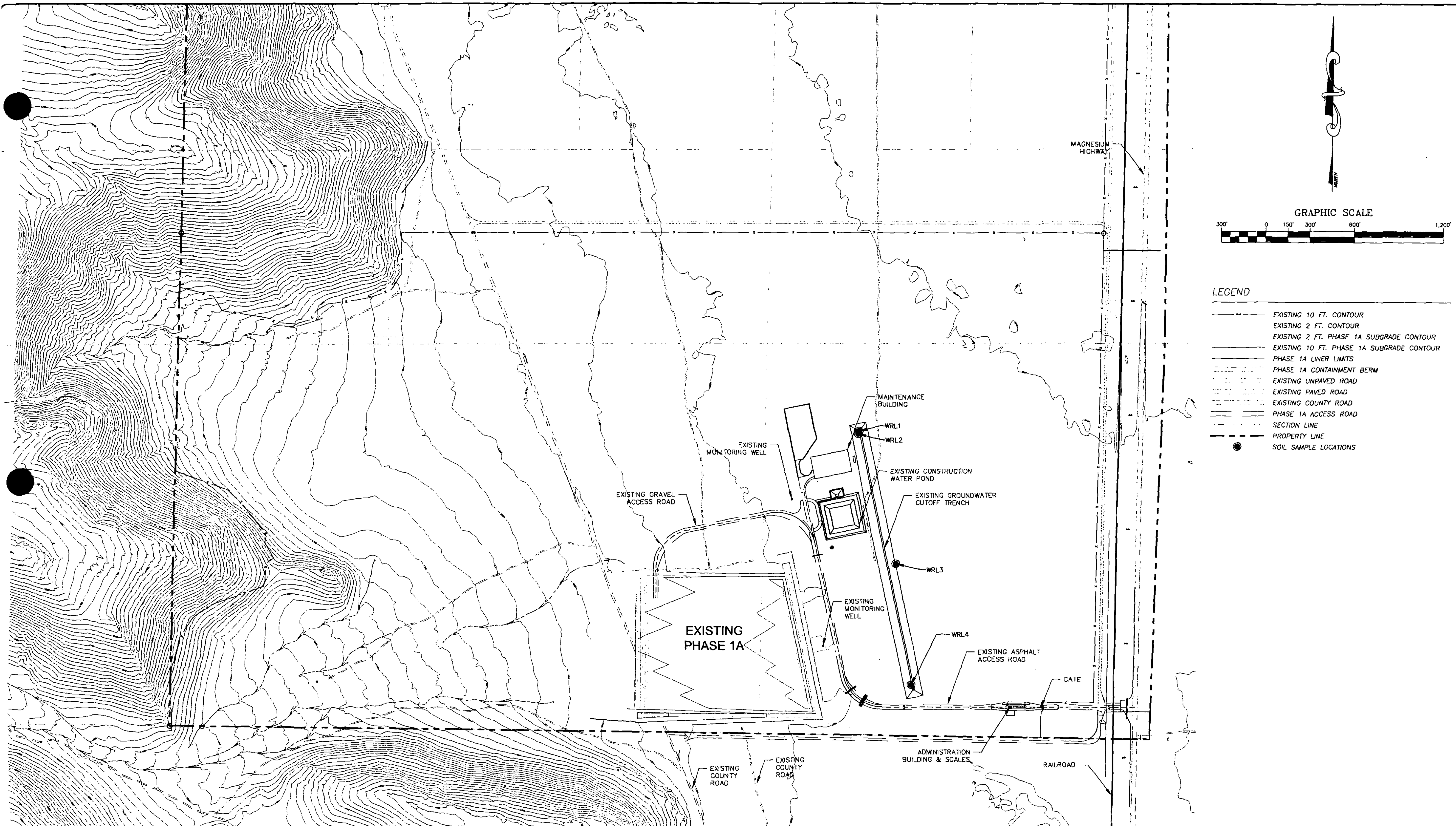
The site climate is arid with an average annual rainfall of 12.9 inches. Maximum precipitation months are March, April, and May, whereas June, July, and August are the drier months of the year. In addition, the site receives an average annual snowfall depth of 33.5 inches (Western Regional Climate Center, www.wrcc.dri.edu).

2.3 Site Investigations and Soils Testing

Previous geotechnical investigations for the WRL were conducted by AGEC (2004), (2005) and Kleinfelder (2004). Results of previous investigations indicate that materials from the potential borrow area consist of soils that will be suitable for an ET cover. Typical ET cover soil properties include liquid limit (LL) less than 50, plasticity index (PI) between 7 and 30, and 35% or greater fines content (i.e., > 35% passing the No. 200 sieve) (ITRC 2003). On-site soils that meet these criteria include lean clays and sandy lean clays, which are present up to depths of 14 feet and are predominantly located in the eastern and northern portions of the proposed borrow area. The silty sands and poorly graded sands that are present on site are not suitable ET cover materials.

The borrow investigation conducted by Vector consisted of logging and sampling four soils from test pits in the proposed borrow area. The approximate test pit locations are shown in Figure 1 and laboratory testing results are included in Appendix A. Classification testing was conducted on all four samples including initial moisture (ASTM D-2216), particle size analysis (ASTM D-422), and Atterberg limits (ASTM D-4318). Two of the four samples were identified as non-plastic sands, and therefore, Atterberg limits testing was not performed on those samples. Additional testing was performed on the two likely ET cover soils including hydraulic property classification such as saturated hydraulic conductivity (i.e., permeability) and soil water characteristic curve (SWCC) testing. All laboratory testing was conducted by Vector in Grass Valley, California.

For purposes of this report, the two potential ET cover soils are referred to herein as Soil No. 1 and Soil No. 2, representing Lab Sample Numbers 1788B and 1788C, respectively (see Appendix A). Sample 1788B was collected from test pit WRL-2, and sample 1788C was collected from test pit WRL-3, shown in Figure 1. Both Soil No. 1 and Soil No. 2 were classified as lean clays (CL).



			BGA	JVR	JVR/TVR	JVR
V. NO.	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY

DATE OF ISSUE: 06/07/06
DESIGNED BY: JVR
DRAWN BY: MH
CHECKED BY: JVR/TVR
APPROVED BY: JVR

VECTOR ENGINEERING, INC.
USA • CENTRAL & SOUTH AMERICA • PHILIPPINES
143E Spring Hill Drive, Grass Valley, CA 95945 +1-530-272-2448 +1-530-272-8533 fax

ALLIED WASTE SERVICES

WASATCH REGIONAL LANDFILL
EVAPOTRANSPIRATIVE FINAL COVER DESIGN
TOOELE COUNTY, UTAH
BORROW SAMPLE LOCATIONS

FIGURE 1
PROJECT NO. 061204.01

2.4 Final Cover Options

2.4.1 Prescriptive Cover

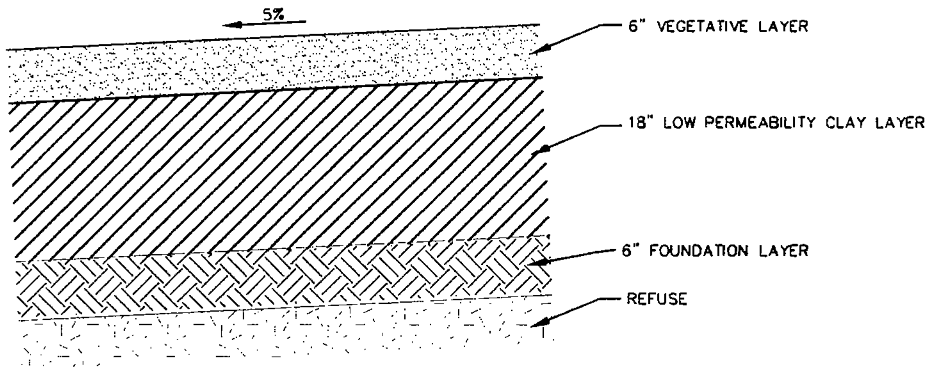
A detail of the standard prescriptive cover is shown in Figure 2. The prescriptive final cover system design (per R315-303-3(4)(a)) consists of an earthen system comprised of an erosion layer underlain by a low-permeability barrier layer. The barrier layer must be at least 18 inches thick and consist of earthen material that has a permeability less than or equal to 1.0 x 10^{-5} cm/s. The erosion layer must consist of 6 inches of earthen material that is capable of sustaining vegetative growth placed over the compacted soil cover and seeded with grass, other shallow rooted vegetation, or other native vegetation.

2.4.2 Alternative Geomembrane Cover

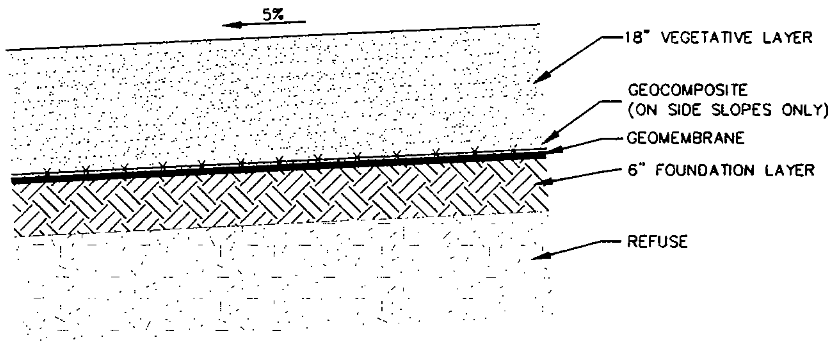
A detail of the geomembrane cover is also shown in Figure 2. An alternative geomembrane cover is the currently proposed closure method for the WRL (Hansen, 2004), and therefore, was analyzed for comparison to the prescriptive and ET covers. Similar to the prescriptive cover, the geomembrane cover is designed to act as a barrier to infiltrating water. From top to bottom, the proposed geomembrane cover consists of a 6-inch vegetative/erosion protection layer, 18 inches of soil, a 60-mil HDPE geomembrane layer, and a 6-inch foundation layer.

2.4.3 Alternative ET Cover

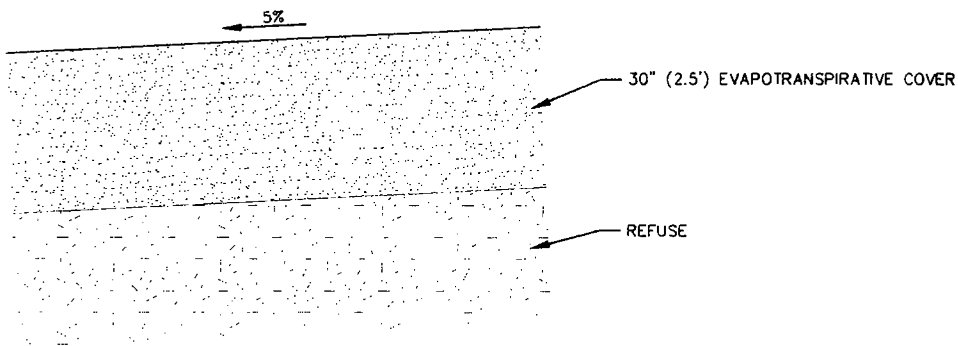
The proposed alternative final cover for the WRL consists of a minimum 2.5-foot thick, ET cover. This ET cover will serve as a barrier to limit water infiltration into the waste by utilizing the storage capacity of fine-grained soils to store precipitation water during wet months coupled with water removal during dry months via evaporation and transpiration. In addition, the cover will act as an erosion control layer to prevent exposure of the underlying waste and provide a medium for the growth of native plants. The soils for the cover material will be obtained from on-site borrow areas.



PRESCRIPTIVE FINAL COVER
TOP DECK



ALTERNATIVE GEOMEMBRANE FINAL COVER
TOP DECK



ALTERNATIVE EVAPOTRANSPIRATIVE (ET) FINAL COVER
TOP DECK

VECTOR ENGINEERING, INC. California • Colorado • Argentina • Brazil • Chile • Peru • Philippines 143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448 (530) 272-8533 fax	FINAL COVER SOIL PROFILES	FIGURE
	ALLIED WASTE INC. Wasatch Regional Landfill TOOELE COUNTY, UTAH	2
JOB NO. 061204.00 APPR. MAC DATE: 06/05/06		

Low permeability soil covers (i.e., prescriptive covers) comprised primarily of high plasticity clays are susceptible to desiccation cracking during wetting-drying cycles, which creates preferential flow paths for water and degraded cover performance with time (Albrecht and Benson, 2001). ET covers utilize soils that are not susceptible to desiccation cracking and offer superior long-term cover performance in regions where annual potential evapotranspiration exceeds precipitation, such as in Tooele County, Utah.

3.0 PERCOLATION ANALYSES

3.1 General

A monolithic ET cover system at the WRL was evaluated to assess its post-closure potential to minimize infiltration of precipitation water into the landfill. Precipitation that infiltrates into a landfill governs the amount of leachate production and is influenced by the design of the cover system. The analyses described herein were performed by simulating the water balance (i.e., precipitation, surface runoff, infiltration, evaporation, transpiration, soil storage, and percolation) of the unsaturated media consisting of the cover system for a 5-year period.

Modeling of the alternative ET cover system was performed for the WRL to evaluate the potential percolation through 2-foot, 2.5-foot, 3-foot, and 4-foot thick monolithic ET covers of varying soil types. ET cover simulations were performed using the computer model UNSAT-H (version 3.01). In addition, percolation performance was also evaluated for a prescriptive barrier cover and an alternative geomembrane cover using the computer model HELP (version 3.06). The following sections provide a discussion of the simulations performed to estimate the potential volume of percolation through the prescriptive cover, geomembrane cover, and monolithic ET cover. The discussion includes descriptions of the computer models used to perform the analyses, the climatological, plant, and soil characteristic input parameters, as well as the results of the analyses.

3.2 HELP

3.2.1 Method of Analysis

Percolation through a prescriptive cover and an alternative geomembrane cover was estimated using HELP version 3.06. The U.S. Army Corps of Engineers (USCOE) first generated the HELP model in 1983 under a contract with the United States Environmental Protection Agency (USEPA). Documentation of version 3.0 of the

HELP model can be found in Schroeder et al. (1994). The results of the HELP modeling are presented in Appendix B.

The HELP model is a quasi-two-dimensional, deterministic, water balance model that utilizes daily climate data, soil and refuse characteristics, and cover/liner system design data to predict the movement of water into, within, and out of landfill boundaries. The daily climate data, which consist of precipitation, temperature and solar radiation values, can be generated synthetically for up to 100 years of daily values by the HELP model from a database or can be defined by the user. The HELP model includes default climate data from 139 U.S. cities, five types of vegetative cover, soil characteristics for 42 soil types and geosynthetic liners, and run-off curve numbers for the default soil and vegetation types. The HELP model allows the user to modify these default parameters to values that are specific to the design and the location of the landfill.

Once the daily climate data is established, either synthetically or by the program's user, and the soil characteristics and design criteria are defined, the movement of water within a landfill is apportioned into various hydrologic processes such as runoff, infiltration, interception, evapotranspiration, percolation, lateral drainage and soil moisture storage. These constituents are used to conduct daily water balance analyses, which are sequentially simulated over a specified time-duration.

3.2.2 Model Input

3.2.2.1 Climatological Input

Precipitation data was obtained from the Callister Ranch weather station (No. 421149) in Tooele County, Utah. Average annual precipitation at the site is 12.9 inches. For HELP model simulations, a the maximum precipitation year on record totaling 16.7 inches was repeated five times resulting in a conservative 5-year simulation period. Daily measured precipitation totals were input into the model, and average daily temperatures were synthetically generated in the model based on normal mean monthly temperatures from the Callister Ranch weather station. In addition, daily solar radiation was synthetically generated by the HELP model based on the parameters for Salt Lake City, Utah. Additional model input pertinent to evapotranspiration (ET) calculations include the evapotranspirative zone depth, maximum leaf area index (LAI), growing season start and end day, average annual wind speed, and average quarterly relative humidity. The ET parameters used in these analyses are summarized in Table 1.

TABLE 1
ESTIMATED EVAPOTRANSPIRATION DATA FOR TOOELE COUNTY, UTAH

Evapotranspiration Zone Depth (in)	24.0
Maximum Leaf Area Index	1.00
Growing Season Start Day (Julian Date)	117
Growing Season End Day (Julian Date)	289
Average Annual Wind Speed (mph)	8.8
Avg. First Quarter Relative Humidity (%)	67.0
Avg. Second Quarter Relative Humidity (%)	48.0
Avg. Third Quarter Relative Humidity (%)	39.0
Avg. Fourth Quarter Relative Humidity (%)	65.0

The average annual snowfall measured at the Callister Ranch weather station is equal to 37.4 inches, and the highest annual snowfall on record is 70.5 inches. Snow accumulation is accounted for in simulations using the HELP model.

3.2.2.2 Soil Properties

The soil profiles for prescriptive barrier and alternative geomembrane covers are shown in Figure 2, and a summary of soil properties is summarized in Table 2. The prescriptive cover system on the top deck and the side slopes would be comprised of a 6-inch thick vegetative soil cover layer overlying a 18-inch thick barrier soil layer.

TABLE 2
SUMMARY OF HELP MODEL LAYER INPUT PARAMETERS

COVER SECTION	LAYER DESCRIPTION	THICKNESS (in)	HYDRAULIC CONDUCTIVITY (CM/SEC)	POROSITY (VOL/VOL)	FIELD CAPACITY (VOL/VOL)	WILTING POINT (VOL/VOL)
Geomembrane Barrier	Vegetative Layer (1)	24	5.8×10^{-6}	0.455	0.363	0.208
	Geomembrane	0.06	2.0×10^{-13}	NA	NA	NA
	Bottom Foundation (1)	12	5.8×10^{-6}	0.455	0.363	0.208
Prescriptive Soil Barrier	Erosion Layer	6	6.4×10^{-5}	0.464	0.310	0.187
	Barrier Layer	18	1.0×10^{-5}	0.464	0.310	0.187

(1) Soil parameters used in HELP analyses are based on laboratory testing performed by Vector.

Soil properties for the vegetative layer and foundation layers of the geomembrane cover were specified based on measured hydraulic properties of an on-site lean clay (sample ID 1788C). The vegetative soil layer for the geomembrane cover was designated as a vertical percolation layer with initial moisture content approximately equal to optimum moisture for that soil type. Similarly, the underlying foundation layer was specified as a vertical percolation layer with initial moisture equal to the optimum moisture content. The saturated hydraulic conductivity (K_s) for both the vegetative and foundation layers was specified at 5.8×10^{-6} centimeters per second (cm/s), as was measured for sample 1788C in the laboratory. The second layer, consisting of the 60-mil HDPE geomembrane was designated as a type 4 flexible membrane liner with a geosynthetic classification obtained from the default menu in the HELP model (material texture number 35). The placement quality was assumed to be "good" with 3 installation defects and 3 pinholes per acre, which are typical industry values.

For modeling of the prescriptive barrier cover, the 6-inch-thick erosion layer was specified as a vertical percolation layer with HELP model default properties for a low plasticity clay (material texture number 11). The soil properties for the 18-inch-thick barrier layer of the prescriptive cover were consistent with HELP material texture number 11 with the exception of the K_s. The required K_s of 1.0×10^{-5} cm/sec, as is specified in R315-303-3(4)(a), was selected to simulate the permeability of this layer. This layer was designated as a type 3 barrier soil liner. The HELP model does not allow manipulation of the initial moisture content if the layer is designated as a barrier soil; therefore, the initial moisture content is automatically set equal to the porosity of the soil.

HELP also allows the user to specify several surface runoff parameters. A runoff curve number (CN) of 87.6, a runoff area of 100 percent, and no initial surface water inflow from snow or ice were selected to define the runoff conditions for the cover. A runoff area of 100 percent was selected in order to be consistent with UNSAT-H model simulations.

3.3 UNSAT-H

3.3.1 Method of Analysis

The water balance for the alternative landfill cover was analyzed using Version 3.01 of UNSAT-H, which is a one-dimensional, finite difference computer program (Fayer, 2000). UNSAT-H simulates liquid water flow through soils by solving Richards' partial differential equation to describe unsaturated liquid and vapor flow in soil, plant uptake, and surface flux (i.e., infiltration and evaporation). Water vapor diffusion is solved using Fick's law and sensible heat flow is solved using the Fourier equation. The water balance includes precipitation, infiltration, surface runoff, evaporation, plant transpiration, water storage, and percolation.

3.3.2 Model Input

3.3.2.1 Nodal Discretization

One-dimensional nodal spacing for the cover thickness is specified by the user in the vertical direction using UNSAT-H. The nodal spacing near surface and interface boundaries are very small (i.e., 0.1 cm), whereas nodal spacing is larger in the middle of each layer (i.e., 7 cm). Smaller node spacing is necessary at the surface in order to obtain an accurate solution due to large and/or rapid changes in suction head at the surface from precipitation and evaporation. In addition, smaller nodal spacing is necessary at the soil-to-soil interface to obtain an accurate solution for soils with significantly different hydraulic properties. In general, a larger number of nodes provides a more accurate solution, but requires more computer simulation time. The 2-foot, 2.5-foot, 3-foot, and 4-foot thick profiles were discretized with 20, 28, 30, and 35 nodes, respectively. In addition, a 9-inch thick waste layer was simulated beneath the cover layer with 10 nodes in order to alleviate lower boundary condition effects. The water flux across the interface between the cover soil and the waste layer was noted as percolation, or leakage through the cover.

3.3.2.2 Climatological Input

The climatological data required in UNSAT-H consists of daily values of precipitation (P) and potential evapotranspiration (PET). Daily precipitation and PET used as climatological input are shown in Figure 3. The daily precipitation data was obtained from the Callister Ranch weather station (No. 421149). In contrast, daily PET data was not available from the Callister Ranch weather station. Therefore, PET data was obtained from the nearby weather station at the Saltair Salt Plant (No. 427578) in Salt Lake City, UT. (Hydrodata version 4.05).

The average annual precipitation for the WRL is 12.9 inches. For modeling, as recommended by Benson (2004), the maximum precipitation year totaling 16.7 inches of precipitation was repeated five times sequentially, resulting in a conservative 5-year simulation period with a total of 83.5 inches of rainfall. Precipitation events were applied at a constant rate throughout the duration of the entire day (i.e., 24 hours), resulting in conservative rainfall intensities and minimized surface runoff predictions. Daily ET data was presented as actual measured pan evaporation. The resulting annual P/PET ratio is 0.22 for climatological input in this analysis.

Snow accumulation is not accounted for in the UNSAT-H model. Simulating a snow pack can be advantageous for regions were significant snowfall occurs because the result is a slower release of water into the cover system as the snow melts. However, Ogorzalek (2005) reported that the water balance of two ET covers in semi-arid regions was not significantly affected by the inclusion of snow accumulation using a similar Richards' equation based model, VADOSE/W. In this analysis, snow-water infiltration was simulated by applying the daily snow-water equivalent (SWE) as rainfall precipitation at a conservative intensity (i.e., 24 hrs). In addition, a snowpack was accounted for in simulations by setting PET = 0 for the months of December, January, February, and March.

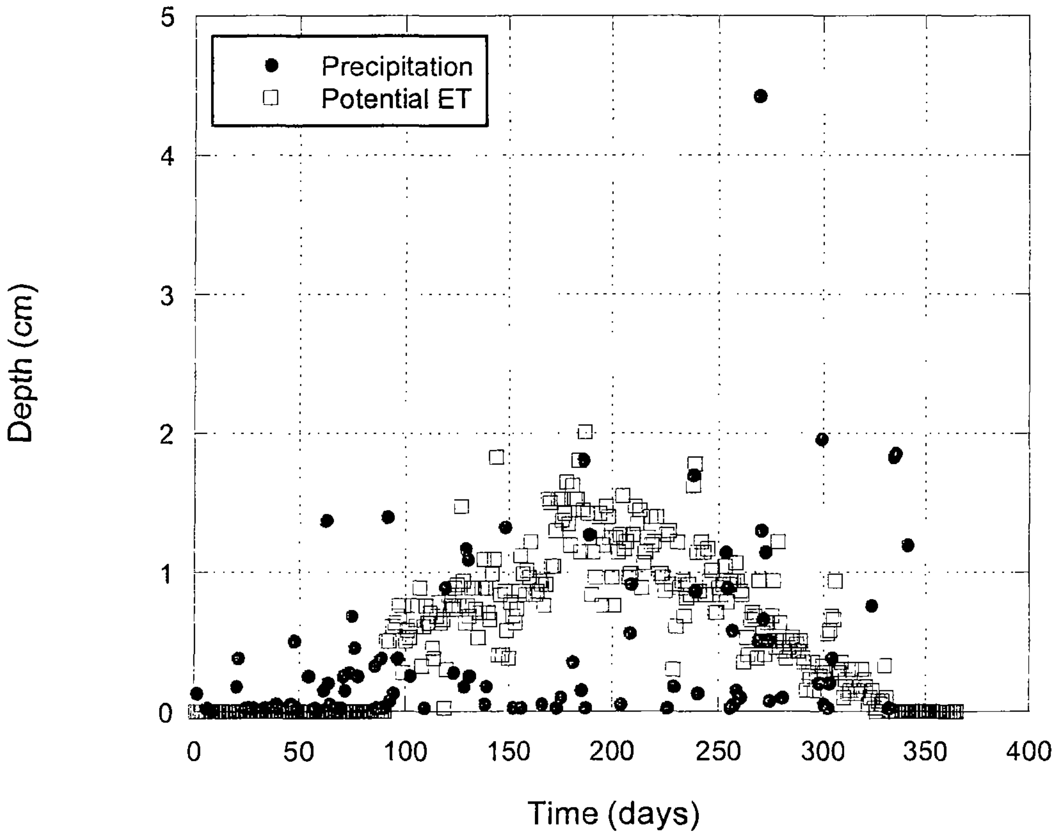


Figure 3
Annual Precipitation and Potential Evapotranspiration used as Model Input

<u>3.3.2.3 Soil Properties</u>

The soil hydraulic properties of the ET cover soil that were used in these analyses are summarized in Table 3. The required soil hydraulic properties include the unsaturated hydraulic conductivity function as well as the soil-water retention characteristics, otherwise known as the soil-water characteristic curve (SWCC). The SWCCs were defined using van Genuchten parameters (van Genuchten 1980), and the unsaturated hydraulic conductivity functions were defined using the corresponding van Genuchten parameters in conjunction with the saturated hydraulic conductivity (K_s). The van Genuchten SWCC fits for the two potential on-site cover soils are shown in Figure 4. Hydraulic properties were determined from laboratory testing conducted by Vector.

TABLE 3
HYDRAULIC PROPERTIES FOR ET COVER SOILS

SOIL NO.	SAMPLE ID	Initial Moisture (vol/vol)	KSAT (CM/SEC)	VAN GENUCHTEN PARAMETERS (UNSAT-H)			
				α (CM^{-1})	n	θ_R	θ_S
1	1788B	0.320	1.50E-05	0.0315	1.0967	0.0000	0.4860
2	1788C	0.306	5.80E-06	0.0110	1.1535	0.0000	0.4548

Soil numbers 1 and 2 were both classified as lean clays. The K_s ranged from 5.8 x 10^{-6} (soil No. 2) to 1.5 x 10^{-5} (soil No. 1). Results of simulations with different soil types are analyzed below in Sections 3.4 and 3.5 for surface runoff and percolation, respectively.

The pore interaction term, l, in the van Genuchten (1980) conductivity equation affects the unsaturated hydraulic conductivity of the material being described. Van Genuchten (1980) recommended a value equal to 0.5 for the pore interaction term. However, Bohnhoff (2005) states that values ranging from -3 to -1 for l result in reduced surface runoff predictions and therefore improved water balance predictions for ET covers. In addition, Schaap and Leij (2000) noted that unsaturated hydraulic conductivity for fine-textured soils is more accurately represented with l ranging from -6 to -1. Decreasing the value of l conservatively increases the unsaturated hydraulic conductivity of a soil. Therefore, a value of -1.0 was specified to describe the pore interaction term for the cover material in these analyses.

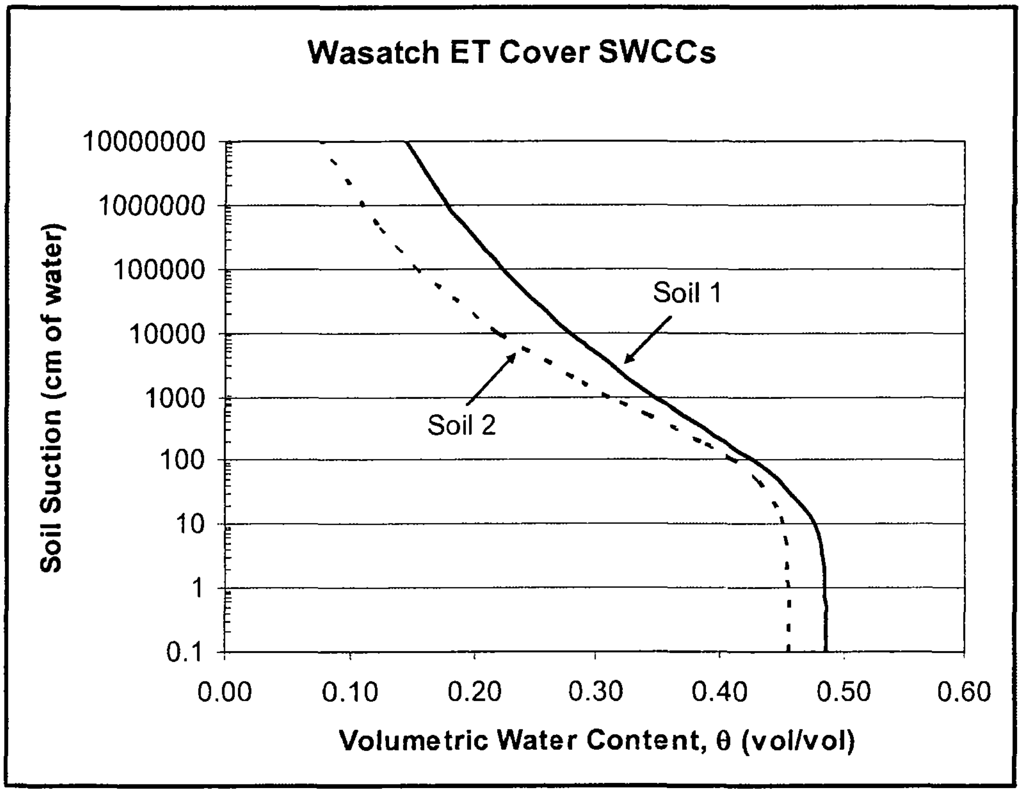


Figure 4
Soil water characteristic curves (SWCCs) as defined by the van Genuchten (1980) equation for two on-site soils at the Wasatch Regional Landfill.

The 9-inch underlying waste layer was defined with typical hydraulic properties for municipal solid waste (MSW), including $K_s = 1 \times 10^{-3}$ cm/s, $\theta_s = 0.53$, $\theta_r = 0.11$, $\alpha = 0.260$ cm^{-1}, and n = 2.22 (Benson 2004). The SWCC for MSW is included in Appendix F.

3.3.2.4 Initial Conditions

The initial conditions for the UNSAT-H modeling consist of defining the initial suction head for each soil type being modeled. Suction heads were specified corresponding to the optimum water content and 90% compaction (ASTM D-698) for each soil type. Initial conditions for soil numbers 1 and 2 are shown in Table 3. In addition, an initial volumetric water content of 12.0%, or 100 cm suction head was specified for the MSW.

3.3.2.5 Plant Parameters

UNSAT-H models plant transpiration based on estimated PET that is calculated from historical climatic data and is modeled as a sink term in Richards' equation for water flow. The sink term is calculated in a three-step process. First, the PET is partitioned into potential evaporation (PE) and potential transpiration (PT) based on the user-specified leaf area index (LAI) for the day in question. Second, PT is distributed throughout the root zone in proportion to the root density at each respective depth. Third, actual transpiration (AT) is derived from the PT in conjunction with the water content, or available water, at each node.

Numerous plant parameters are required for the analyses including percent of plant coverage, LAI, daily PET data, start and end days of plant growth cycle, number and magnitude of LAI changes during the year, growth day for each corresponding root depth, the water content below which plants wilt and stop transpiring (i.e., wilting point), the water content below which plant transpiration starts to decrease (i.e., limiting point), and water content above which plants do not transpire due to anaerobic conditions (i.e., anaerobisis point).

The ET cover simulations in these analyses included conservative assumptions of a maximum LAI of 1.0 to describe the plant canopy. The maximum root depth was assumed to be 3 feet, or the bottom of the cover material for the 2 foot and 2.5 foot cover section. Root growth equation parameters are as follows: a = 1.163, b = 0.129, and c = 0.02 (Fayer 2000). The start and end days of plant growth cycle used in this analysis are Julian days 117 and 289, respectively, which were the HELP model defaults for Salt Lake City, UT. Typical values of 15,000 cm, 333 cm, and 30 cm were used for the wilting point, limiting point, and anaerobisis point, respectively.

3.4 Surface Runoff Results

A summary of surface runoff predictions is shown in Table 4. Surface runoff predictions in ET cover design are affected by the K_s of the surface layer soil (Bohnhoff, 2005, Ogorzalek, 2005, Scanlon et al., 2002). Low surface runoff predictions result in higher infiltration, which is conservative with respect to cover design because more water is available for percolation. In order to minimize surface runoff and maximize infiltration of precipitation water, Richards' equation based models can be "tricked" by simulating a thin layer at the surface with a high K_s (Newman, 2004). In addition, use of a thin surface layer with high K_s better represents the high conductivities associated with actual surface conditions due to desiccation cracking and biota intrusion. Therefore, a 1 cm surface layer with a K_s equal to 1×10^{-4} cm/s and the same water retention parameters as the cover soil was used to reduce surface runoff predictions in these analyses.

TABLE 4
COMPARISON OF SURFACE RUNOFF (SRO) PREDICTIONS

COVER SECTION	MODEL	AVG. PREDICTED SRO, mm/yr (% of annual precipitation)	
		Soil No. 1	Soil No. 2
2 Foot ET	UNSAT-H	92 (21.7%)	65 (15.3%)
2.5 Foot ET	UNSAT-H	103 (24.3%)	107 (25.1%)
3 Foot ET	UNSAT-H	106 (24.8%)	107 (25.1%)
4 Foot ET	UNSAT-H	107 (25.1%)	108 (25.3%)
Geomembrane	HELP	22 (5.2%)	
Prescriptive Barrier	HELP	18 (4.1%)	

In addition to the 1 cm surface layer with high K_s, surface runoff predictions also were reduced by using a value of -1 for the pore interaction term, l, in the van Genuchten conductivity equation, as was discussed above in section 3.3.2.2. Decreasing l from 0.5 to -1 results in higher unsaturated hydraulic conductivities, and therefore, higher infiltration into the cover. Precipitation events were applied at conservative intensities, which also contributes to reduced surface runoff predictions (see 3.3.2.5 above).

3.5 Percolation Results

3.5.1 HELP Results

HELP model results are summarized in Table 5 in terms of annual percolation during the 5th year of a 5-year simulation period, and HELP model output files are included in Appendix B. For the 5 times repeated maximum precipitation year simulations, the geomembrane cover system performed better than the prescriptive cover system with 0.34 mm predicted percolation for the geomembrane cover and 83.35 mm predicted percolation for the prescriptive cover during the 5th and final simulation year.

3.5.2 UNSAT-H Results

The 5th year percolation results utilizing the UNSAT-H model for a 5-year simulation period are summarized in Table 5. The input files for the 2-foot, 2.5-foot, 3-foot, and 4-foot thick ET covers are included in Appendix C, and UNSAT-H output files are included in Appendix D. Cumulative percolation plots are included in Appendix E. The predicted percolation through ET cover configurations during the fifth year of simulation for the WRL ranges from 0.00 mm to 33.8 mm for the two soil types and four cover thicknesses analyzed. ET cover simulations with Soil No. 1 resulted in less than 3 mm/yr of predicted percolation during the fifth year of simulation only for the 4 foot cover thickness. In contrast, Soil No. 2 resulted in less than 3 mm/yr of predicted percolation during the 5th simulation year for 2.5-foot, 3-foot, and 4-foot ET cover thicknesses. The higher percolation rates using Soil No. 1 can be attributed to the high permeability of 1.5 x 10^{-5} cm/s measured for that soil. Therefore, based on UNSAT-H simulations with Soil No. 1, a 4-foot thick ET cover will be required and with Soil No. 2, a 2.5-foot thick ET cover will be required to meet the UDEQ's equivalency criteria of 3 mm/yr of percolation into the waste.

TABLE 5
COMPARISON OF 5th YEAR COVER PERCOLATION PREDICTIONS (mm)

COVER SECTION	MODEL	SOIL NO.1 ($K=1.5x10^{-5}cm/s$)	SOIL NO.2 ($K=5.8x10^{-6}cm/s$)
2 Foot ET	UNSAT-H	33.76	13.95
2.5 Foot ET	UNSAT-H	31.75	0.000
3 Foot ET	UNSAT-H	20.31	0.000
4 Foot ET	UNSAT-H	0.000	0.000
Geomembrane	HELP	0.340	
Prescriptive Barrier	HELP	83.35	

If ET cover soils are consistent with Soil No. 2 in this report, and soils consistent with Soil No. 1 are avoided, then analyses have shown that a 2.5-foot ET cover will provide adequate storage to prevent excessive percolation at the WRL.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Cover Performance Comparison

Alternative ET covers should be designed to meet equivalent performance with respect to estimated percolation (i.e., drainage into the waste) of a prescribed (barrier) cover for a particular application and region. The estimated annual percolation of a prescriptive barrier cover at the WRL was 83.35 mm based on HELP model simulations. However, in previous ET cover reports, the UDEQ established an equivalency criterion of 3 mm/yr of cumulative percolation. Water balance simulations using UNSAT-H resulted in less than 3 mm/yr of percolation with a 2.5-foot thick ET cover comprised of Soil No. 2 and a 4-foot thick ET cover comprised of Soil No. 1 at the WRL. Vector's recommendation is a 2.5-foot thick ET cover comprised of soils that are consistent with Soil No. 2 in this report.

4.2 ET Cover Soil Classification

For a 2.5-foot ET cover to be constructed at the WRL, soils shall meet the following criteria:

- LL $\leq$ 35
- 7 $\leq$ PI $\leq$ 16
- > 35 % passing the No. 200 sieve.
- Permeability $\leq 5.8 \times 10^{-6}$ cm/s

Based on previous boring logs and geotechnical investigations at the WRL (AGEC, 2004, 2005 and Kleinfelder, 2004), the recommended soils are believed to be present in the potential borrow area primarily near the surface and up to depths of 14 feet below the ground surface. Vector also recognizes the abundance of soil types located in the proposed borrow area at the WRL, and if soils that are to be used as ET cover material do not meet the above stated criteria, then further hydraulic property testing and unsaturated flow modeling shall be conducted to determine suitability of that material.

4.3 Erosion Control

Due to the soil types that will be used for closure construction, erosion of the landfill surface may occur. Soil loss analyses should be performed for the WRL using the Universal Soil Loss Equation developed by the United States Department of Agriculture (1965) or other suitable method. Erosion will be minimized by placing riprap or other suitable erosion control materials within all the channels and at other concentrated flow locations. The topsoil surface should also be seeded with an approved native grass mix with maximum potential for transpiration to promote vegetative growth and water removal from the cover. The seed mix shall be specified by an approved plant specialist. The cover system should be closely monitored during the post-closure period for the presence of excessive erosion. Erosion gullies should be regraded and additional fill placed as necessary to ensure that the integrity of the cover is not compromised.

4.4 Surface Water Hydraulic Considerations

The WRL final cover drainage structures should be designed to collect the run-off from a 100-year, 24-hour storm event. At closure, the top surface should be sloped a minimum 3%. Sheet flow off of the top should be collected by soil berms placed at the crest of the top slope.

The benches should drain to main collection points where water will be transported down to the perimeter ditches using corrugated metal or HDPE downdrains. Channels should be constructed along the inside of each berm. Each of these channels should be graded to drain at a minimum of 0.5% slope to specified downdrains located at various locations around each unit. The channels should be lined with riprap, cobble, gravel, or other suitable materials to minimize erosion along these lines of concentrated flow. Due to the large amount of energy that is generated in the downdrains, a tee section or other energy dissipater should be installed at the bottom of each downdrain where water is discharged into the perimeter channels.

In addition, an apron of riprap or other approved material should be placed at the discharge end of the culverts located throughout the site to dissipate energy and minimize erosion immediately downstream of their outlets.

4.5 Cover Construction Plan

Construction of the cover system should be performed in accordance with the final construction drawings, specifications and other contract documents. Construction quality assurance (CQA) should be performed throughout construction to ensure that the cover system and related facilities are installed in accordance with the plans and specifications.

During placement of the cover, the Contractor should be required to place the soils to the required thickness and grades provided on the design drawings. A field survey should be performed to ensure that adequate materials and the minimum grading requirements are established. Once the cover materials are placed in a given area, the Contractor should install the drainage facilities. The Contractor should take extreme care not to damage the cover layer or other structures. The drainage facilities construction should be monitored on full-time basis so that any damages are recorded and repaired in a timely manner.

5.0 LIMITATIONS

The engineering analyses presented in this report are based upon field observations, laboratory testing, and our understanding of the project. This report was prepared in accordance with generally accepted soils engineering practices applicable at the time the report was prepared. Vector Engineering, Inc. makes no other warranties, either expressed or implied, as to the professional opinions and conclusions provided.

The scope of our services did not include an environmental assessment or investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater or air, on, below, or around this site.

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APPENDIX A
Soil Investigation Summary

VECTOR ENGINEERING, INC.

DATE: May 3, 2006

TO: Jake Russel

JOB NO: 061204.00
LAB LOG: 1788.0

e-mail: russell@vectoreng.com

RE: **Lab Report: Wasatch Regional Landfill**

Enclosed are results for: Samples Received - April 18, 2006

Code	Item	Quantity
19544	Water Content, ASTM D-2216	4
19523	Sieve Analysis, ASTM D-422 wo/Hydrometer	4
19534	Atterberg Limits, ASTM D-4318	2
11500	Standard Compaction-4", ASTM D-698	2
18568	Hydraulic Conductivity-Flex-wall, Remolded, ASTM D-5084	2

Thank you for consulting Vector Engineering for your material testing requirements. We look forward to working with you again. If you have any questions or require any additional information, please call us at 1-530-272-2448.

Sincerely,

M Dell-Era

Prepared By: Margaret Dell-Era
Laboratory Administrator

Reviewed By: Kenneth R. Criley
Technical Director

143E Spring Hill Drive • Grass Valley, California 95945 • (530) 272-2448 • Fax: (530) 272-8533
USA • Central & South America • Philippines

LT-1-AF (rev.2-10-04)

Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448
LABORATORY SERVICES

AS-RECEIVED WATER CONTENT and DRY DENSITY

QC Data Check

Client: **Allied Waste Inc.** Project Name: **Wasatch Regional Landfill** Project Number: **061204.00** Lab Log Number: **1788**

	Lab Sample Number	(LSN)	**1788A**	**1788B**	**1788C**	**1788D**						
	Sample Identification		WRL-1	WRL-2	WRL-3	WRL-4						
	Oven, Microwave, or Air Dry											
	WATER CONTENT											
A	Date / By:		4/18 eco	4/18 eco	4/18 eco	4/18 eco						
B	Tare No.:		d17	d118	d125	d11						
C	Tare + Wet Soil mass (g):		263.89	265.91	189.29	285.39						
D	Tare Dry Soil mass (g):		245.79	217.08	170.55	250.83						
E	Moisture Loss mass (g):	*C - D*	18.10	48.83	18.74	34.56						
F	Tare mass (g):		50.92	50.75	49.89	51.25						
G	Dry Soil mass (g):	*D - F*	194.87	166.33	120.66	199.58						
H	Water Content (%):	*E / G * 100*	***9.29***	***29.36***	***15.53***	***17.32***						
	DENSITY											
I	Tube + Wet Soil mass (g):											
J	Tube mass (g):											
K	Wet Soil mass (g):	*I - J*										
L	Sample Length (in):											
M	Sample Diameter (in):											
N	Sample Length (cm):	*L * 2.54*										
O	Sample Diameter (cm):	*M * 2.54*										
P	Sample Area (cm^2):	$\pi * (O)^2 / 4$										
Q	Volume (cm^3):	*P * N*										
R	Wet Density (g/cm^3):	*K / Q*										
S	Wet Density (pcf):	*R * 62.43*										
T	Dry Density (pcf):	*S / (1+(H/100))*										
U	Specific Gravity (assume 2.7)		2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
V	Void Ratio:	*((U * 62.43) / T) -1*										
W	Saturation (%):	*(U * H) / V*										
X	Porosity (%):	*(V / (1+V))*100*										

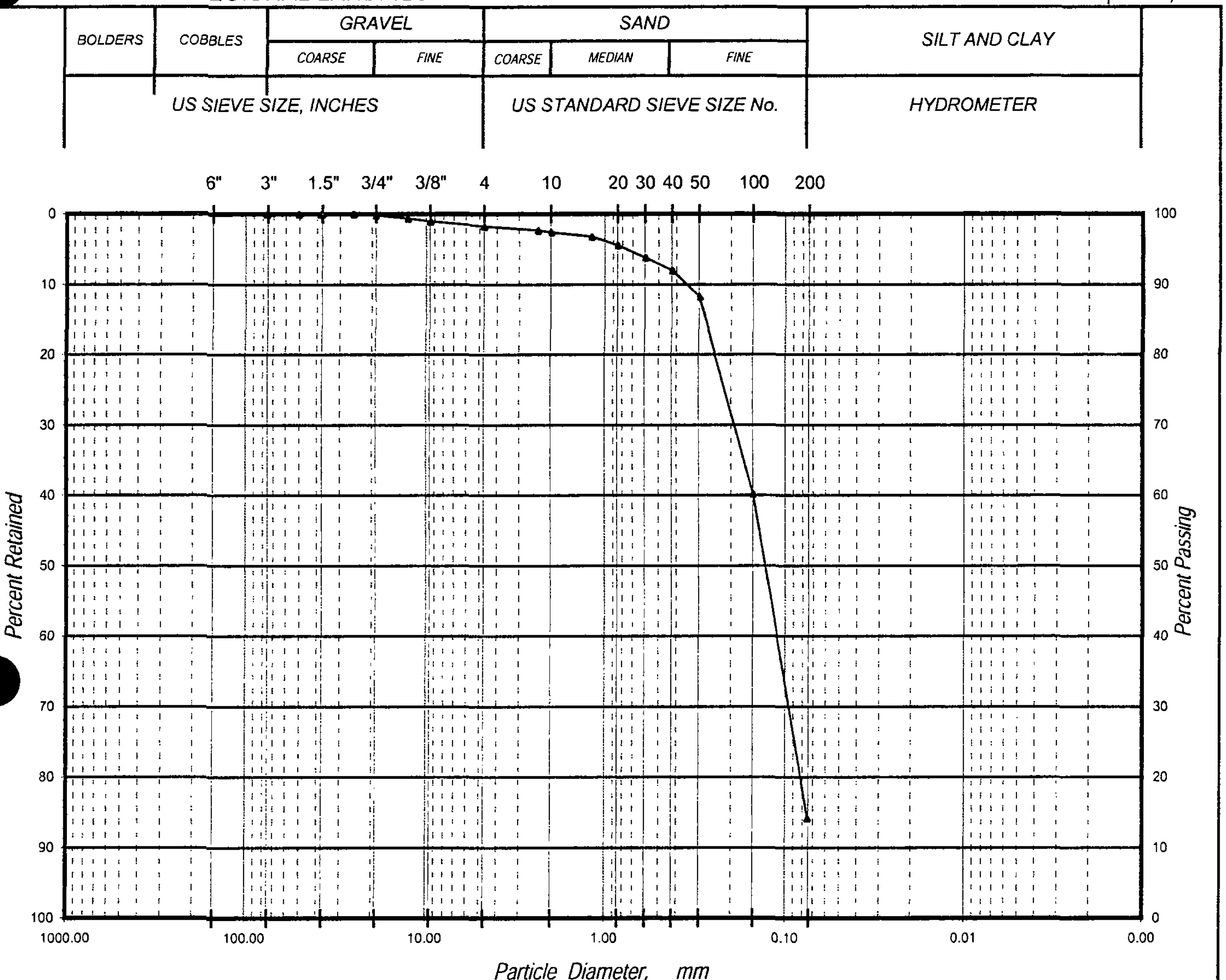
L: Labexcel\Projects\2006\061204\1788-MD-ck.xls Print Date: 05/03/06 Entered By: eco Reviewed by: Lab Log Number: **1788**

DCN: MD (rev. 04/28/03)

Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 530-272-2448
LABORATORY SERVICES

PARTICLE SIZE ANALYSIS
TEST REPORT
ASTM D-422

Client: ALLIED WASTE INC.
Project No: 061204.00
Lab Sample No: **1788A**
Project Name: WASATCH REGIONAL LANDFILL
Report Date: April 24, 2006



Symbol	Sample ID	Description	% Gravel	% Sand	% Silt - Clay
▲	WRL 1- (15' deep) (Rec'd 4/18/06)	Silty Sand	1.7	84.2	14.1

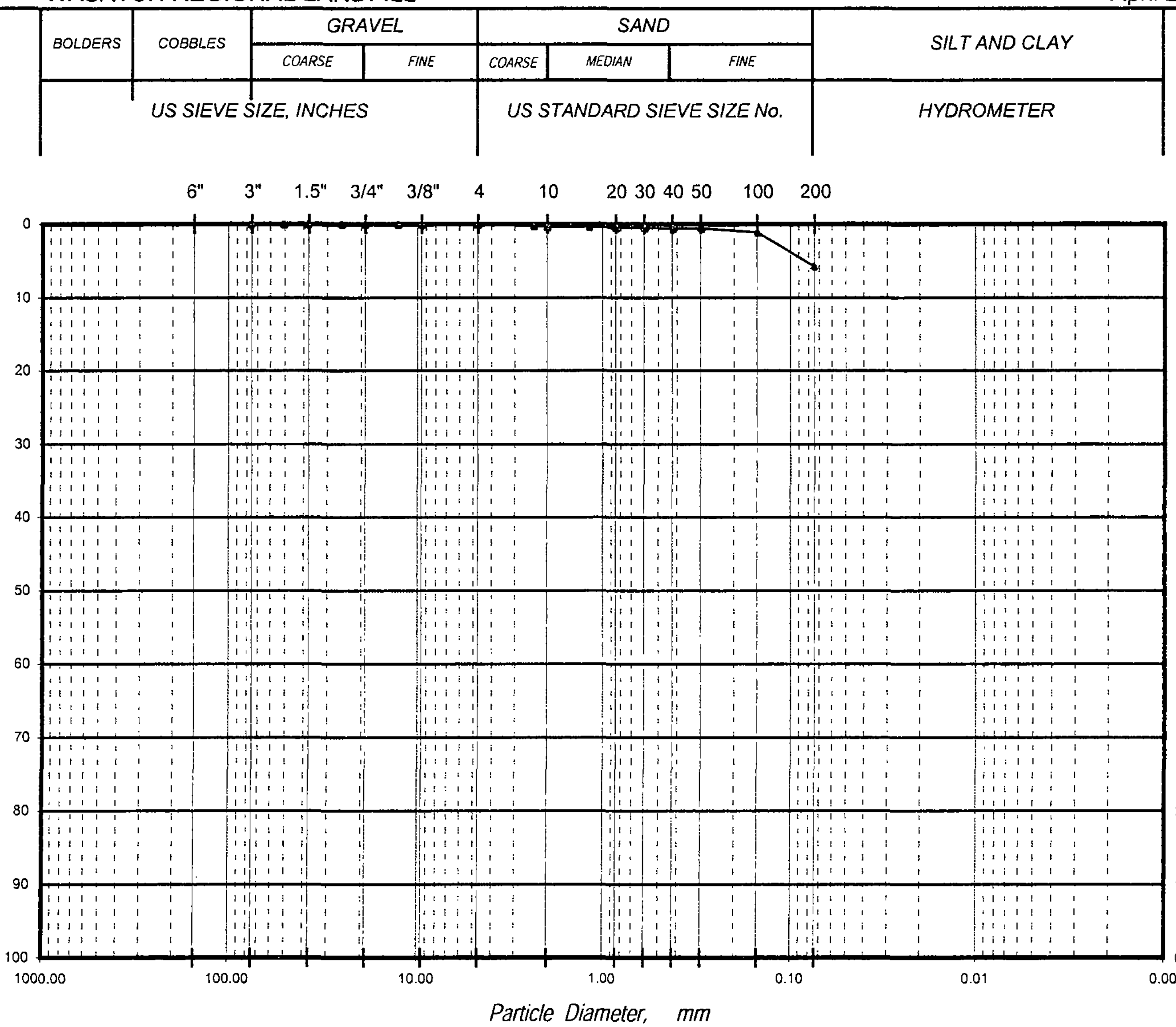
Size Passing, mm D_{60} = 0.15 D_{30} = 0.10 D_{10} = N/A

Coefficient of Curvature, C_c: N/A Coefficient of Uniformity, C_u: N/A Fineness Modulus = 0.66

Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 530-272-2448
LABORATORY SERVICES

PARTICLE SIZE ANALYSIS
TEST REPORT
ASTM D-422

Client:	Project No:	Lab Sample No:
ALLIED WASTE INC.	061204.00	**1788B**
...ct Name: WASATCH REGIONAL LANDFILL		Report Date: April 24, 2006



Symbol	Sample ID	Description	% Gravel	% Sand	% Silt - Clay
▲	WRL 2 - (10' deep) (Rec.4/17/06)	Weathered Clay	0.0	5.7	94.3

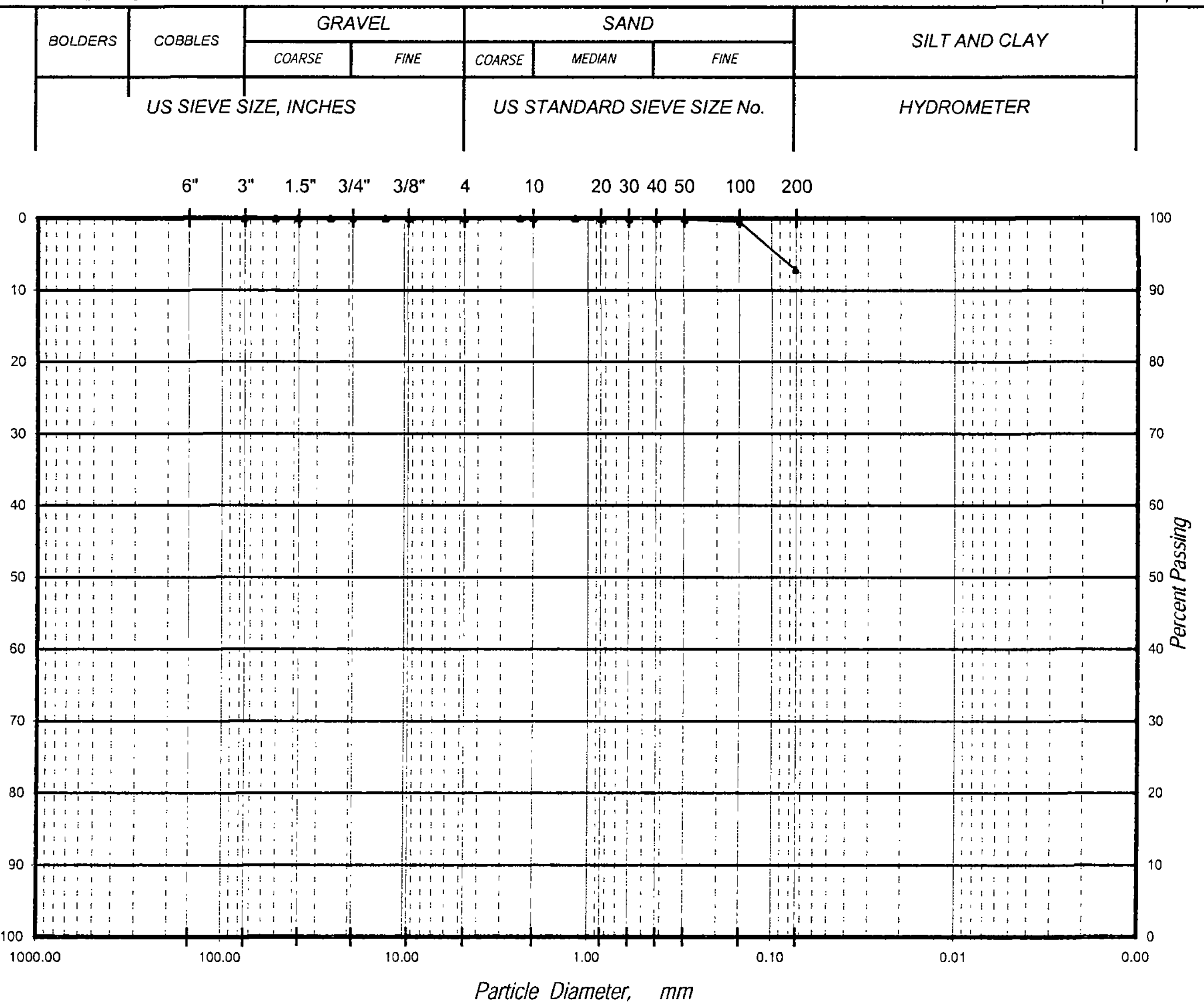
Size Passing, mm D_{60} = N/A D_{30} = N/A D_{10} = N/A

Coefficient of Curvature, C_c: N/A Coefficient of Uniformity, C_u: N/A Fineness Modulus = 0.03

Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 530-272-2448
LABORATORY SERVICES

PARTICLE SIZE ANALYSIS
TEST REPORT
ASTM D-422

Client: ALLIED WASTE INC.
Project No: 061204.00
Lab Sample No: **1788C**
Project Name: WASATCH REGIONAL LANDFILL
Report Date: April 24, 2006



Symbol	Sample ID	Description	% Gravel	% Sand	% Silt - Clay
▲	WRL 3 - (3' deep) E side of pond (Rec. 4/17)	Clay Topsoil	0.0	7.1	92.9

Size Passing, mm D_{60} = N/A D_{30} = N/A D_{10} = N/A

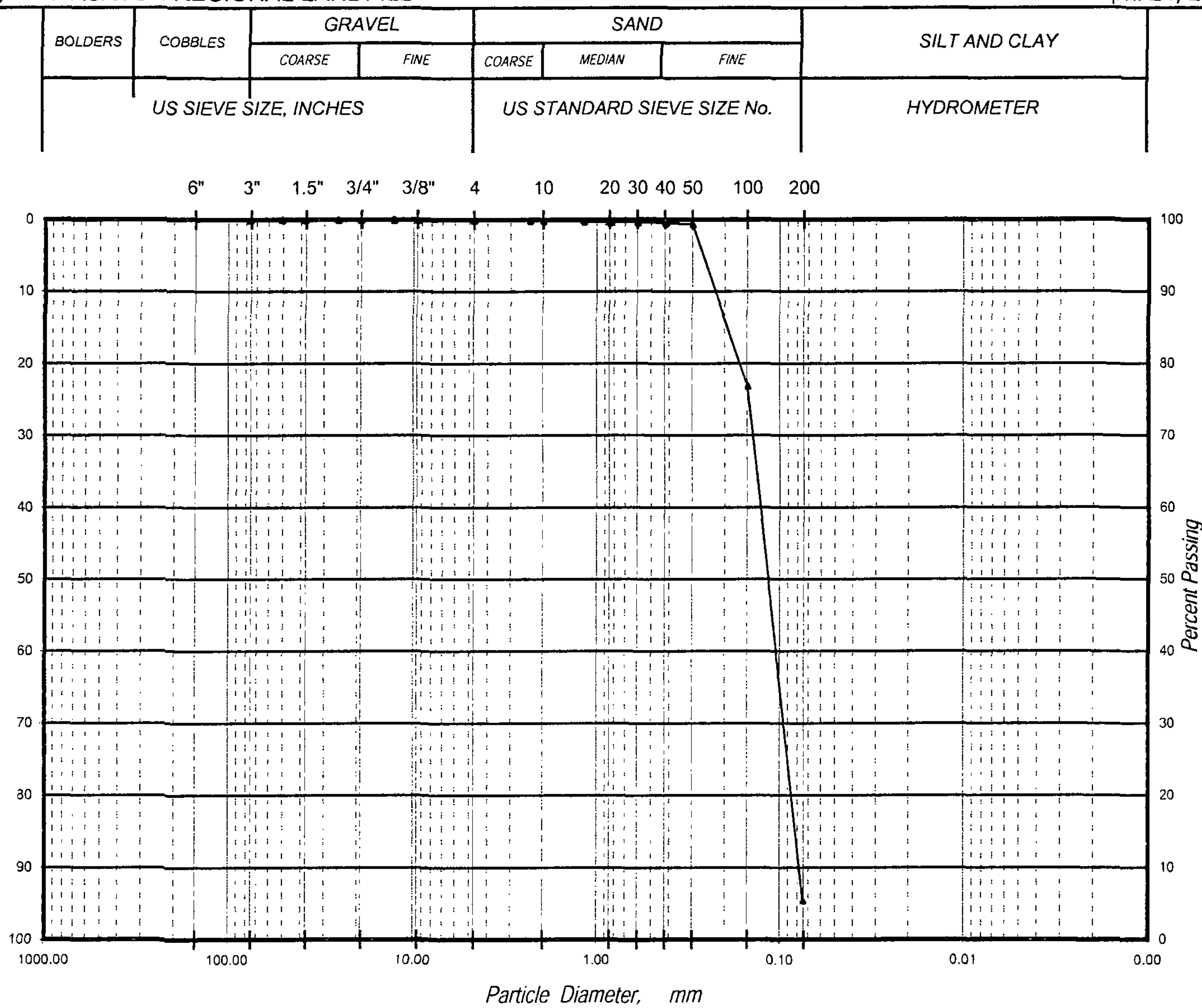
Coefficient of Curvature, C_c: N/A Coefficient of Uniformity, C_u: N/A Fineness Modulus = 0.01

Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 530-272-2448
LABORATORY SERVICES

PARTICLE SIZE ANALYSIS
TEST REPORT
ASTM D-422

Client: ALLIED WASTE INC.
Project No: 061204.00
Lab Sample No: **1788D**

Project Name: WASATCH REGIONAL LANDFILL
Report Date: April 24, 2006



Symbol	Sample ID	Description	% Gravel	% Sand	% Silt - Clay
▲	WRL 4 -S End of Borrow (25' deep) (Rec'd 4/18/06)	Fine Sand w/ Silt	0.0	94.5	5.5

Size Passing, mm D_{60} = 0.13 D_{30} = 0.10 D_{10} = 0.08

Coefficient of Curvature, C_c: 0.96 Coefficient of Uniformity, C_u: 1.66 Fineness Modulus = 0.24

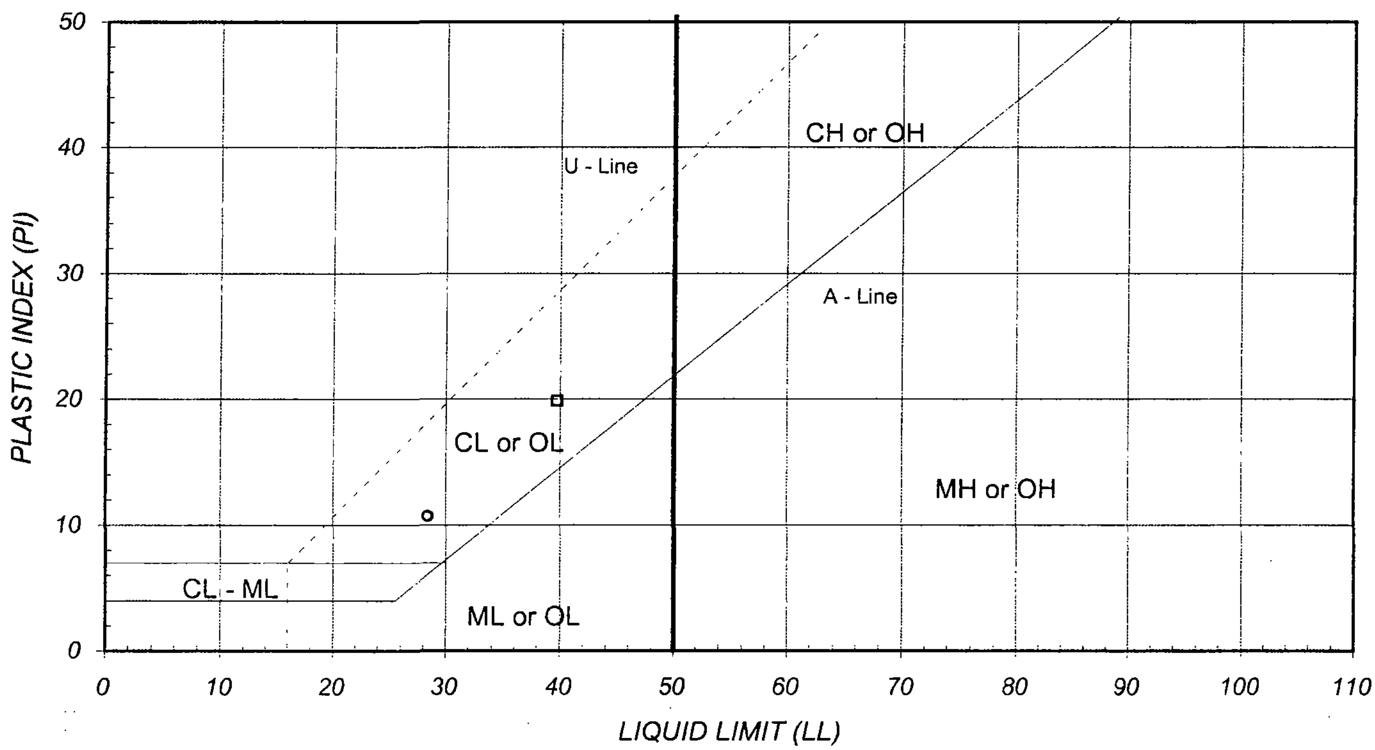
Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448
LABORATORY SERVICES

ATTERBERG LIMITS
Summary Report
ASTM D-4318

Client: Allied Waste
Project No: 061204.00
Lab Log No.: **1788**
Project Name: Wasatch Regional LF
Report Date: April 27, 2006

LSN	SYMBOL	SAMPLE IDENTIFICATION	SAMPLE DESCRIPTION	UNIFIED SYMBOL	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
1788B	□	WRL-2 @ 10'	Weathered Clay	CL	40	20	20
1788C	○	WRL-3 E Side of Pond @ 3'	Clay Topsoil	CL	28	18	11

PLASTICITY CHART



These results apply only to the above listed samples. The data and information are proprietary and can not be released without authorization of Vector Engineering Inc. By accepting the data and results represented on this page, client agrees to limit the liability of Vector Engineering, Inc. from Client and all other parties claims arising out of the use of this data to the cost for the respective test(s) represented here, and Client agrees to indemnify and hold harmless Vector from and against all liability in excess of the aforementioned limit.

L : Labexcel \ Projects \2006 \ 061204 \ 1788-PI-Base.xls
Print Date: 05/03/06
Entered By: SC
Rev. By:
Lab Log No.: **1788**

DCN: PI-rp (rev. 3/14/03)

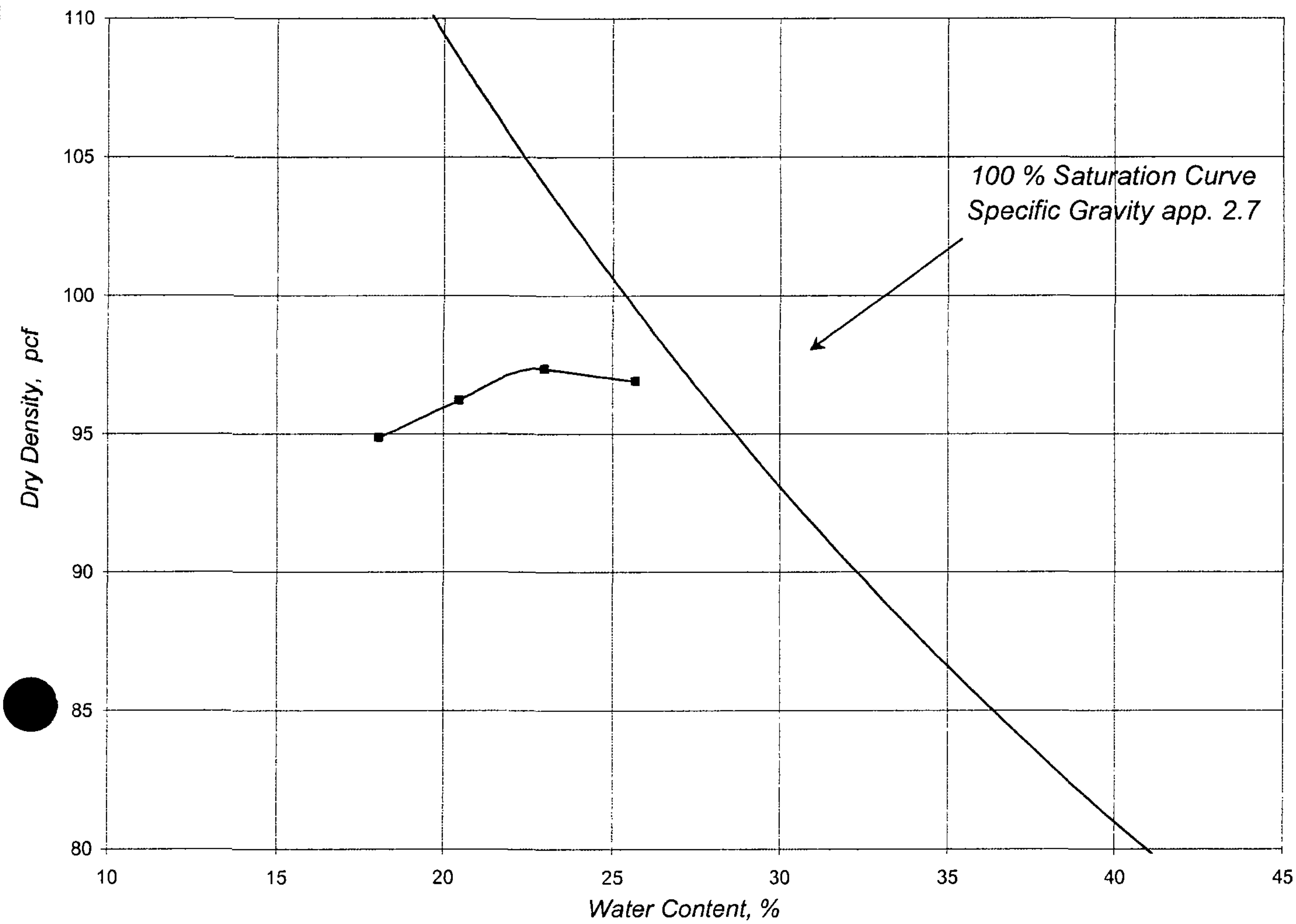
Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448
LABORATORY SERVICES

MOISTURE / DENSITY RELATIONSHIPS

TEST REPORT

ASTM D - 698

Client: Allied Waste Inc.
Project No.: 061204.00
Lab Log No.: **1788B**
Project Name: Wasatch Regional Landfill
Report Date: April 24, 2006



Symbol	Lab No.	Sample Identification	Description	Maximum Dry Density pcf	Maximum Dry Density kg / m³	Optimum Water Content %
■	1788B	WRL 2 -(10' deep) (Rec'd 4/18/06)	Weathered Clay	97.4	1.56	22.8

Corrected Values For Oversized Particles, per ASTM D-4718

■ 1788B with 0 Percent + #4 Gravel, the maximum Dry Density = 97.4 22.8

Note: The test was conducted as method A with 0 percent retained on the no. 4 sieve (minus 3/4")

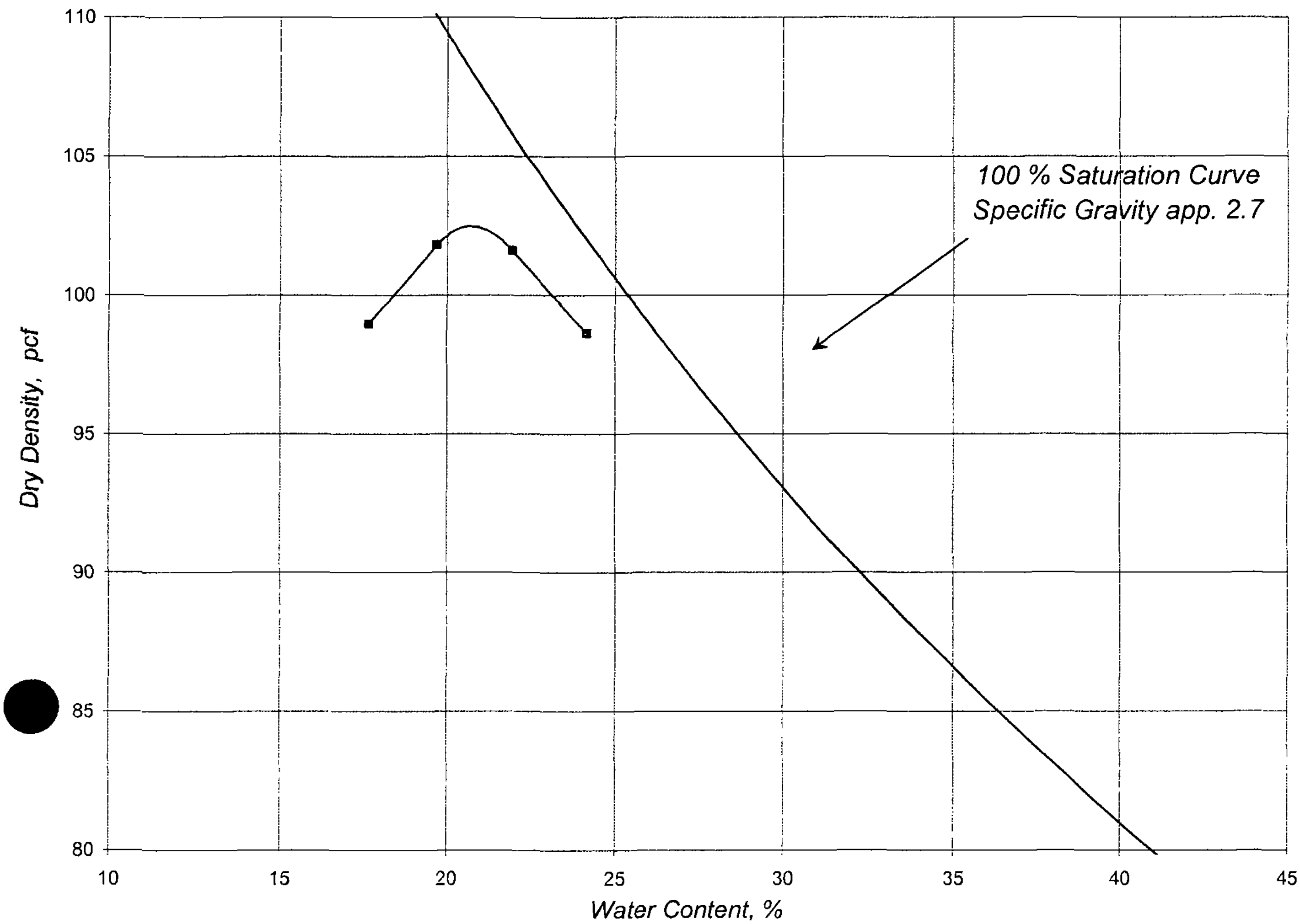
Vector Engineering Inc.
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448
LABORATORY SERVICES

MOISTURE / DENSITY RELATIONSHIPS

TEST REPORT

ASTM D - 698

Client: Allied Waste Inc.
Project No.: 061204.00
Lab Log No.: **1788C**
Project Name: Wasatch Regional Landfill
Report Date: April 24, 2006



Symbol	Lab No.	Sample Identification	Description	Maximum Dry Density pcf	Maximum Dry Density kg / m³	Optimum Water Content %
■	1788C	WRL 3-(3' deep) E side of Pond (Rec.4/18)	Clay Topsoil	102.5	1.64	20.7

Corrected Values For Oversized Particles, per ASTM D-4718

■ 1788C with 0 Percent + #4 Gravel, the maximum Dry Density = 102.5 20.7

Note: The test was conducted as method A with 0 percent retained on the no. 4 sieve (minus 3/4")

Vector Engineering, Inc.

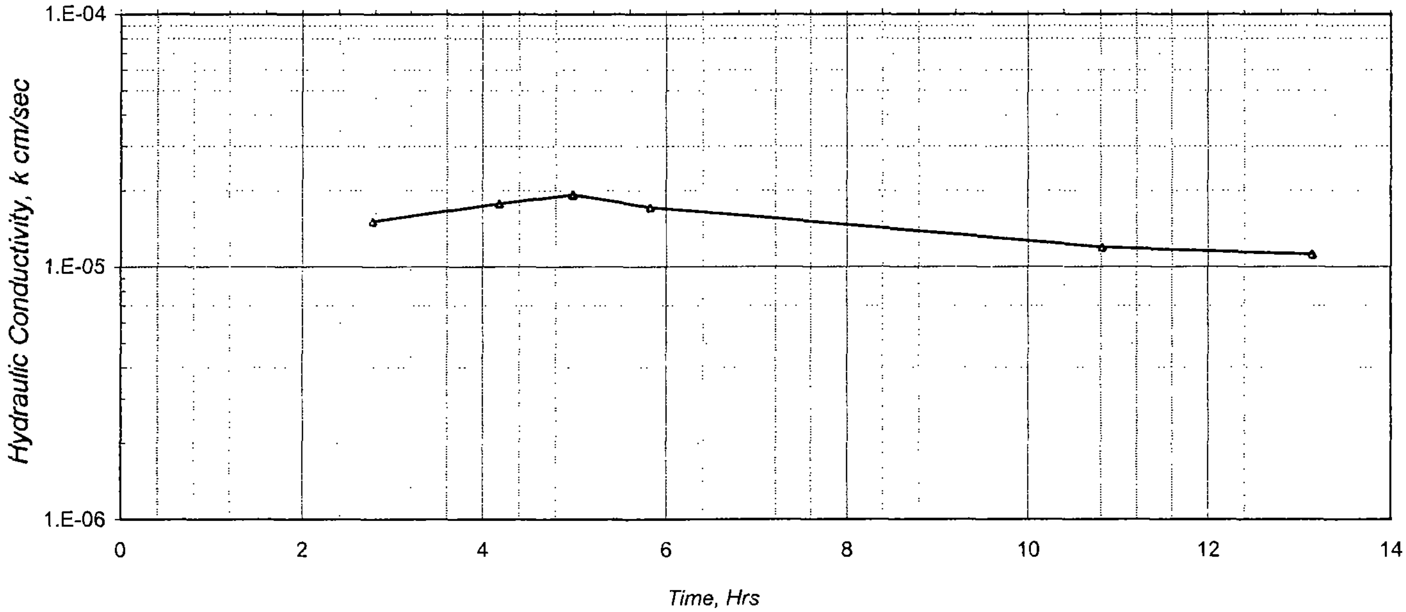
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

HYDRAULIC CONDUCTIVITY REPORT

Client / Project Name: **Allied Waste Inc./Wasatch Regional LF**
Project No: **061204.00**
Lab Sample Number: **1788B**

Sample ID: **WRL 2 - (10' deep)**
Report Date: **May 3, 2006**



SPECIMEN DATA

SAMPLE ID:	**WRL 2 - (10' deep)**	
DESCRIPTION:	Weathered Clay	
	INITIAL	FINAL
HEIGHT, in.	3.0	3.0
DIAMETER, in.	2.4	2.5
WATER CONTENT, %	24.2	36.1
DRY DENSITY, pcf	87	84
SATURATION, %	69	97
(Specific Gravity assumed as 2.7)		
MAXIMUM DRY DENSITY, pcf	97.4	
OPTIMUM WATER CONTENT, %	22.8	
SPECIFIED COMPACTION, %	90.0	
ACHIEVED COMPACTION, %	88.9	

COMMENTS:

Tap water used as permeant.

TEST DATA

ASTM D-5084, Method C

EFFECTIVE STRESS:	1 psi
GRADIENT RANGE:	0 - 11
IN / OUT RATIO:	1.03
"B" PARAMETER:	0.95

TRIAL nos.	TIME hrs.	HYDRAULIC CONDUCTIVITY cm / sec
1	5.8	1.7E-05
2	4.2	1.8E-05
3	5.0	1.9E-05
4	5.8	1.7E-05
5	10.8	1.2E-05
6	13.1	1.1E-05

AVERAGE LAST 4 : **1.5E-05**

Vector Engineering, Inc.

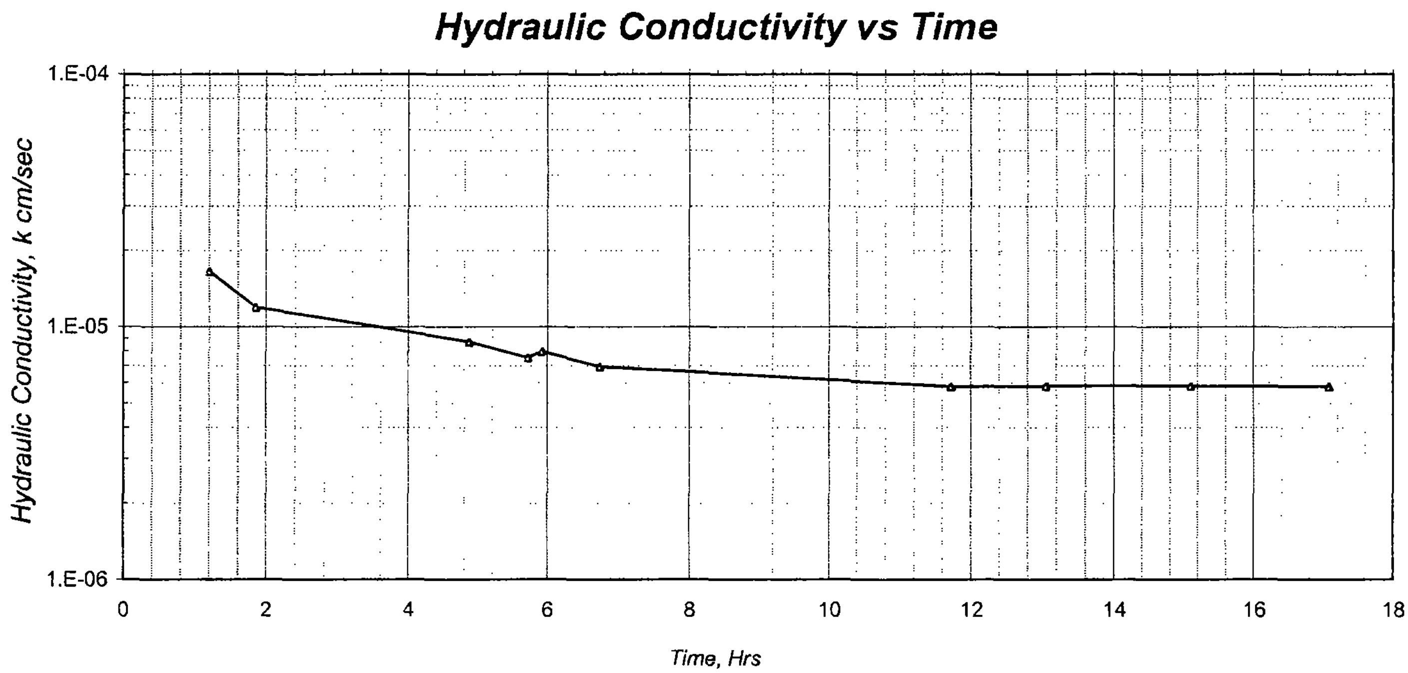
143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

HYDRAULIC CONDUCTIVITY REPORT

Client / Project Name: **Allied Waste Inc./Wasatch Regional LF**
Project No: **061204.00**
Lab Sample Number: **1788C**

Sample ID: **WRL 3- (3' deep) E Side of Pond**
Report Date: **May 3, 2006**



SPECIMEN DATA

SAMPLE ID:	WRL 3- (3' deep) E Side of Pond	
DESCRIPTION:	Clay Topsoil	
	INITIAL	FINAL
HEIGHT, in.	3.0	3.0
DIAMETER, in.	2.4	2.4
WATER CONTENT, %	21.2	29.4
DRY DENSITY, pcf	92	93
SATURATION, %	69	98
(Specific Gravity assumed as 2.7)		
MAXIMUM DRY DENSITY, pcf	102.5	
OPTIMUM WATER CONTENT, %	20.7	
SPECIFIED COMPACTION, %	90.0	
ACHIEVED COMPACTION, %	89.6	

COMMENTS:

Tap water used as permeant.

TEST DATA

ASTM D-5084, Method C

EFFECTIVE STRESS:	1 psi
GRADIENT RANGE:	1 - 12
IN / OUT RATIO:	1.00
"B" PARAMETER:	0.95

TRIAL nos.	TIME hrs.	HYDRAULIC CONDUCTIVITY cm / sec
4	5.7	5.8E-06
5	5.9	8.0E-06
6	6.7	7.0E-06
7	11.7	5.8E-06
8	13.1	5.8E-06
9	15.1	5.8E-06
10	17.1	5.8E-06

AVERAGE LAST 4 : **5.8E-06**

APPENDIX B
HELP MODEL OUTPUT FILES

Prescriptive Barrier Cover

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**             HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**               HELP MODEL VERSION 3.06   (17 AUGUST 1996)                 **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     N:\WASATCH\ALTERN~1\HELP\WRL01.D4
TEMPERATURE DATA FILE:       N:\WASATCH\ALTERN~1\HELP\WRL01.D7
SOLAR RADIATION DATA FILE:   N:\WASATCH\ALTERN~1\HELP\WRL01.D13
EVAPOTRANSPIRATION DATA:     N:\WASATCH\ALTERN~1\HELP\WRL01.D11
SOIL AND DESIGN DATA FILE:   N:\WASATCH\ALTERN~1\HELP\WRL02.D10
OUTPUT DATA FILE:            N:\WASATCH\ALTERN~1\HELP\WRL02.OUT


TIME:  15:49     DATE:   5/25/2006


******************************************************************************

     TITLE:  Wasatch Regional Landfill - Prescriptive Barrier Cover

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =      6.00    INCHES
           POROSITY                   =      0.4640 VOL/VOL
           FIELD CAPACITY             =      0.3100 VOL/VOL
           WILTING POINT              =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2340 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4640 VOL/VOL
FIELD CAPACITY	=	0.3100 VOL/VOL
WILTING POINT	=	0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4640 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	87.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.404	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.784	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.122	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.756	INCHES
TOTAL INITIAL WATER	=	9.756	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Tooele UTAH

STATION LATITUDE	=	40.60	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	117	
END OF GROWING SEASON (JULIAN DATE)	=	289	
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	48.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	39.00	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 65.00 %

NOTE: PRECIPITATION DATA FOR CALLISTER RANCH UTAH
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
27.60	33.70	40.70	47.10	57.00	67.20
75.30	74.20	63.70	50.40	38.40	29.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH
AND STATION LATITUDE = 40.76 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.541	1964.604	3.23
EVAPOTRANSPIRATION	13.023	47273.059	77.79
PERC./LEAKAGE THROUGH LAYER 2	3.178765	11538.918	18.99
AVG. HEAD ON TOP OF LAYER 2	0.0387		
CHANGE IN WATER STORAGE	-0.003	-10.372	-0.02
SOIL WATER AT START OF YEAR	9.756	35414.090	
SOIL WATER AT END OF YEAR	9.753	35403.715	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.010	0.00

****

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.625	2268.458	3.73
EVAPOTRANSPIRATION	12.508	45405.523	74.72
PERC./LEAKAGE THROUGH LAYER 2	3.191812	11586.276	19.07
AVG. HEAD ON TOP OF LAYER 2	0.0358		
CHANGE IN WATER STORAGE	0.415	1505.934	2.48
SOIL WATER AT START OF YEAR	9.753	35403.715	
SOIL WATER AT END OF YEAR	10.168	36909.652	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

****

****

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.760	2760.456	4.54
EVAPOTRANSPIRATION	13.469	48894.273	80.46
PERC./LEAKAGE THROUGH LAYER 2	2.196247	7972.375	13.12
AVG. HEAD ON TOP OF LAYER 2	0.0283		
CHANGE IN WATER STORAGE	0.314	1139.093	1.87
SOIL WATER AT START OF YEAR	10.168	36909.652	
SOIL WATER AT END OF YEAR	10.361	37611.664	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.120	437.081	0.72

ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

****

****

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	1.024	3716.671	6.12
EVAPOTRANSPIRATION	13.879	50379.223	82.91
PERC./LEAKAGE THROUGH LAYER 2	2.235023	8113.134	13.35
AVG. HEAD ON TOP OF LAYER 2	0.0261		
CHANGE IN WATER STORAGE	-0.397	-1442.838	-2.37
SOIL WATER AT START OF YEAR	10.361	37611.664	
SOIL WATER AT END OF YEAR	10.084	36605.906	
SNOW WATER AT START OF YEAR	0.120	437.081	0.72
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.498	1808.069	2.98
EVAPOTRANSPIRATION	13.571	49262.215	81.07
PERC./LEAKAGE THROUGH LAYER 2	3.281419	11911.550	19.60
AVG. HEAD ON TOP OF LAYER 2	0.0353		
CHANGE IN WATER STORAGE	-0.610	-2215.625	-3.65
SOIL WATER AT START OF YEAR	10.084	36605.906	
SOIL WATER AT END OF YEAR	9.474	34390.281	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.010	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.31	0.39	1.95	1.13	1.78	0.23
	1.88	1.14	4.53	1.17	1.18	1.05
STD. DEVIATIONS	0.00	0.00	0.25	0.25	0.00	0.00
	0.00	0.00	0.01	0.01	0.33	0.33
RUNOFF						
TOTALS	0.009	0.004	0.028	0.000	0.000	0.000
	0.000	0.000	0.454	0.001	0.000	0.195
STD. DEVIATIONS	0.013	0.008	0.062	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.214
EVAPOTRANSPIRATION						
TOTALS	0.333	0.778	1.786	1.022	1.458	0.532
	1.615	0.624	2.252	1.194	0.928	0.768
STD. DEVIATIONS	0.063	0.250	0.069	0.053	0.043	0.005
	0.156	0.233	0.136	0.073	0.082	0.244
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0019	0.0382	0.0000	0.0000	0.2547	0.0000
	0.0931	0.1329	1.7200	0.0056	0.0000	0.5702
STD. DEVIATIONS	0.0043	0.0854	0.0000	0.0000	0.0963	0.0000
	0.0371	0.0425	0.0926	0.0038	0.0000	0.4924

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0001	0.0023	0.0000	0.0000	0.0119	0.0000
	0.0044	0.0066	0.3006	0.0002	0.0000	0.0680
STD. DEVIATIONS	0.0001	0.0052	0.0000	0.0000	0.0059	0.0000
	0.0020	0.0019	0.0200	0.0001	0.0000	0.0679

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74 (0.003)	60766.2	100.00
RUNOFF	0.690 (0.2119)	2503.65	4.120
EVAPOTRANSPIRATION	13.290 (0.5338)	48242.86	79.391
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.81665 (0.55024)	10224.451	16.82589
AVERAGE HEAD ON TOP OF LAYER 2	0.033 (0.005)		
CHANGE IN WATER STORAGE	-0.056 (0.4431)	-204.76	-0.337

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	1.74	6316.200
RUNOFF	0.361	1310.9502
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.423342	1536.73303
AVERAGE HEAD ON TOP OF LAYER 2	4.402	
SNOW WATER	1.56	5651.1836
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4467	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870	

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.1220	0.1870
2	8.3520	0.4640
SNOW WATER	0.000	

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Alternative Geomembrane Cover

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**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.06   (17 AUGUST 1996)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
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PRECIPITATION DATA FILE:     N:\WASATCH\ALTERN~1\HELP\WRL01.D4
TEMPERATURE DATA FILE:       N:\WASATCH\ALTERN~1\HELP\WRL01.D7
SOLAR RADIATION DATA FILE:   N:\WASATCH\ALTERN~1\HELP\WRL01.D13
EVAPOTRANSPIRATION DATA:     N:\WASATCH\ALTERN~1\HELP\WRL01.D11
SOIL AND DESIGN DATA FILE:   N:\WASATCH\ALTERN~1\HELP\WRL01.D10
OUTPUT DATA FILE:            N:\WASATCH\ALTERN~1\HELP\WRL01.OUT


TIME:  10:57     DATE:   5/25/2006


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     TITLE:  Wasatch Regional Landfill - Geomembrane Cover

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                     =     24.00   INCHES
          POROSITY                      =      0.4550 VOL/VOL
          FIELD CAPACITY                =      0.3630 VOL/VOL
          WILTING POINT                 =      0.2080 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2793 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.580000005000E-05 CM/SEC
```

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	3.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4550 VOL/VOL
FIELD CAPACITY	=	0.3630 VOL/VOL
WILTING POINT	=	0.2080 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3324 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.580000005000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	87.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	24.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.704	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.920	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.693	INCHES
TOTAL INITIAL WATER	=	10.693	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Tooele UTAH

STATION LATITUDE	=	40.60 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	117
END OF GROWING SEASON (JULIAN DATE)	=	289
EVAPORATIVE ZONE DEPTH	=	24.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	48.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	39.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00 %

NOTE: PRECIPITATION DATA FOR CALLISTER RANCH UTAH
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
27.60	33.70	40.70	47.10	57.00	67.20
75.30	74.20	63.70	50.40	38.40	29.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE CITY UTAH
AND STATION LATITUDE = 40.76 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.602	2185.375	3.60
EVAPOTRANSPIRATION	15.797	57344.379	94.37
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00

AVG. HEAD ON TOP OF LAYER 2	0.0000		
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.341	1236.427	2.03
SOIL WATER AT START OF YEAR	12.145	44085.273	
SOIL WATER AT END OF YEAR	12.485	45321.699	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.017	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.840	3049.690	5.02
EVAPOTRANSPIRATION	14.802	53731.555	88.42
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	1.098	3984.963	6.56
SOIL WATER AT START OF YEAR	12.485	45321.699	
SOIL WATER AT END OF YEAR	13.583	49306.660	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	1.032	3744.900	6.16
EVAPOTRANSPIRATION	17.056	61914.199	101.89
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-1.348	-4892.889	-8.05
SOIL WATER AT START OF YEAR	13.583	49306.660	
SOIL WATER AT END OF YEAR	12.115	43976.691	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.120	437.081	0.72
ANNUAL WATER BUDGET BALANCE	0.0000	-0.012	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	1.319	4786.635	7.88
EVAPOTRANSPIRATION	15.492	56234.832	92.54
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.070	-255.251	-0.42
SOIL WATER AT START OF YEAR	12.115	43976.691	
SOIL WATER AT END OF YEAR	12.165	44158.520	
SNOW WATER AT START OF YEAR	0.120	437.081	0.72
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.74	60766.199	100.00
RUNOFF	0.559	2030.074	3.34
EVAPOTRANSPIRATION	14.130	51291.219	84.41
PERC./LEAKAGE THROUGH LAYER 2	0.001547	5.614	0.01
AVG. HEAD ON TOP OF LAYER 2	0.0136		
PERC./LEAKAGE THROUGH LAYER 3	0.013390	48.604	0.08
CHANGE IN WATER STORAGE	2.038	7396.310	12.17
SOIL WATER AT START OF YEAR	12.165	44158.520	
SOIL WATER AT END OF YEAR	14.202	51554.832	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.31	0.39	1.95	1.13	1.78	0.23
	1.88	1.14	4.53	1.17	1.18	1.05
STD. DEVIATIONS	0.00	0.00	0.25	0.25	0.00	0.00
	0.00	0.00	0.01	0.01	0.33	0.33
RUNOFF						
TOTALS	0.006	0.006	0.057	0.000	0.000	0.000

	0.000	0.000	0.454	0.002	0.004	0.342
STD. DEVIATIONS	0.008	0.010	0.128	0.000	0.000	0.000
	0.000	0.000	0.046	0.001	0.007	0.371

EVAPOTRANSPIRATION

TOTALS	0.311	0.800	1.773	2.027	1.579	0.887
	1.975	0.578	2.045	2.122	0.848	0.512
STD. DEVIATIONS	0.058	0.242	0.068	0.352	0.096	0.203
	0.253	0.042	0.163	0.272	0.208	0.254

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0027
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0326
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0728

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	16.74	(0.003)	60766.2	100.00
RUNOFF	0.870	(0.3149)	3159.33	5.199

EVAPOTRANSPIRATION	15.455	(1.1028)	56103.23	92.326
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.00031	(0.00069)	1.123	0.00185
AVERAGE HEAD ON TOP OF LAYER 2	0.003	(0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00268	(0.00599)	9.721	0.01600
CHANGE IN WATER STORAGE	0.412	(1.2696)	1493.91	2.458

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	1.74	6316.200
RUNOFF	0.531	1927.4042
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.000293	1.06310
AVERAGE HEAD ON TOP OF LAYER 2	1.502	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002322	8.42810
SNOW WATER	1.56	5651.1836

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3747

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2080

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	8.7739	0.3656
2	0.0000	0.0000
3	3.9765	0.3314
SNOW WATER	0.000	

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APPENDIX C
UNSAT-H INPUT FILES

2' ET Cover, Soil No. 1

Wasatch Landfill (2 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

```
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,30,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 7.1,2,12.9,2,18.7,
2,24.5,2,30.5,2,36.5,2,42.3,
2,48.1,2,53.9,2,59.7,2,60.2,
2,60.5,2,60.7,2,60.9,2,61.0,
3,61.1,3,61.3,3,61.5,3,61.8,
3,62.3,3,63.1,3,68.9,3,74.7,
3,80.5,3,86.3,
Surface Layer Moistre Characteristics
0.4860,0.0000,0.0315,1.0967,
Surface Layer Hydraulic Conductivity
2,0.3600,0.0315,1.0967,-1.0,
Weathered Clay w/ Silt Moisture Characteristics
0.4860,0.0000,0.0315,1.0967,
Weathered Clay w/ Silt Hydraulic Conductivity
2,0.0540,0.0315,1.0967,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
 100.0, 100.0, 100.0, 100.0,
 100.0, 100.0, 100.0, 100.0,
 100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
  1,  1,  1,  1,  1,  7,  8,  9, 10, 14,
 17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
365,365,365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,
```

2' ET Cover, Soil No. 2

Wasatch Landfill (2 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,30,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 7.1,2,12.9,2,18.7,
2,24.5,2,30.5,2,36.5,2,42.3,
2,48.1,2,53.9,2,59.7,2,60.2,
2,60.5,2,60.7,2,60.9,2,61.0,
3,61.1,3,61.3,3,61.5,3,61.8,
3,62.3,3,63.1,3,68.9,3,74.7,
3,80.5,3,86.3,
Surface Layer (Lean Clay) Moistre Characteristics
0.4548,0.0000,0.0110,1.1535,
Surface Layer (Lean Clay) Hydraulic Conductivity
2,0.3600,0.0110,1.1535,-1.0,
Lean Clay Moisture Characteristics
0.4548,0.0000,0.0110,1.1535,
Lean Clay Hydraulic Conductivity
2,0.0209,0.0110,1.1535,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
1, 1, 1, 1, 1, 7, 8, 9, 10, 14,
17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
365,365,365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,

2.5' ET Cover, Soil No. 1

Wasatch Landfill (2.5 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,38,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.1,
2,31.1,2,38.1,2,45.1,2,52.1,
2,59.1,2,64.9,2,68.7,2,71.3,
2,73.0,2,74.1,2,74.9,2,75.4,
2,75.7,2,75.9,2,76.1,2,76.2,
3,76.4,3,76.6,3,76.9,3,77.4,
3,78.2,3,84.0,3,89.8,3,95.6,
3,101.4,3,107.2,
Surface Layer Moistre Characteristics
0.4860,0.0000,0.0315,1.0967,
Surface Layer Hydraulic Conductivity
2,0.3600,0.0315,1.0967,-1.0,
Weathered Clay w/ Silt Moisture Characteristics
0.4860,0.0000,0.0315,1.0967,
Weathered Clay w/ Silt Hydraulic Conductivity
2,0.0540,0.0315,1.0967,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
1, 1, 1, 1, 1, 7, 8, 9, 10, 14,
17, 20, 23, 26, 29, 30, 30, 30,365,365,
365,365,365,365,365,365,365,365,365,365,

365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,

2.5' ET Cover, Soil No. 2

Wasatch Landfill (2.5 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,38,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.1,
2,31.1,2,38.1,2,45.1,2,52.1,
2,59.1,2,64.9,2,68.7,2,71.3,
2,73.0,2,74.1,2,74.9,2,75.4,
2,75.7,2,75.9,2,76.1,2,76.2,
3,76.4,3,76.6,3,76.9,3,77.4,
3,78.2,3,84.0,3,89.8,3,95.6,
3,101.4,3,107.2,
Surface Layer (Lean Clay) Moistre Characteristics
0.4548,0.0000,0.0110,1.1535,
Surface Layer (Lean Clay) Hydraulic Conductivity
2,0.3600,0.0110,1.1535,-1.0,
Lean Clay Moisture Characteristics
0.4548,0.0000,0.0110,1.1535,
Lean Clay Hydraulic Conductivity
2,0.0209,0.0110,1.1535,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
1, 1, 1, 1, 1, 7, 8, 9, 10, 14,
17, 20, 23, 26, 29, 30, 30, 30,365,365,
365,365,365,365,365,365,365,365,365,365,

365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,

3' ET Cover, Soil No. 1

Wasatch Landfill (3 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

```
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,40,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.3,
2,31.5,2,38.7,2,45.9,2,53.1,
2,60.3,2,67.5,2,74.7,2,80.5,
2,84.3,2,86.9,2,88.6,2,89.7,
2,90.5,2,91.0,2,91.3,2,91.5,
2,91.7,2,91.8,3,91.9,3,92.1,
3,92.6,3,93.4,3,94.7,3,96.8,
3,100.0,3,105.0,3,110.0,3,115.0,
Surface Layer Moistre Characteristics
0.4860,0.0000,0.0315,1.0967,
Surface Layer Hydraulic Conductivity
2,0.3600,0.0315,1.0967,-1.0,
Weathered Clay w/ Silt Moisture Characteristics
0.4860,0.0000,0.0315,1.0967,
Weathered Clay w/ Silt Hydraulic Conductivity
2,0.0540,0.0315,1.0967,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0, 100.0, 100.0,
 100.0, 100.0, 100.0, 100.0,
 100.0, 100.0, 100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
 1,  1,  1,  1,  1,  7,  8,  9, 10, 14,
 17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
 30, 30, 30, 30, 30,365,365,365,365,365,
```

```
365,365,365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,
```

3' ET Cover, Soil No. 2

Wasatch Landfill (3 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,40,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.3,
2,31.5,2,38.7,2,45.9,2,53.1,
2,60.3,2,67.5,2,74.7,2,80.5,
2,84.3,2,86.9,2,88.6,2,89.7,
2,90.5,2,91.0,2,91.3,2,91.5,
2,91.7,2,91.8,3,91.9,3,92.1,
3,92.6,3,93.4,3,94.7,3,96.8,
3,100.0,3,105.0,3,110.0,3,115.0,
Surface Layer (Lean Clay) Moistre Characteristics
0.4548,0.0000,0.0110,1.1535,
Surface Layer (Lean Clay) Hydraulic Conductivity
2,0.3600,0.0110,1.1535,-1.0,
Lean Clay Moisture Characteristics
0.4548,0.0000,0.0110,1.1535,
Lean Clay Hydraulic Conductivity
2,0.0209,0.0110,1.1535,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
1.163,0.129,0.02,
1, 1, 1, 1, 1, 7, 8, 9, 10, 14,
17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
30, 30, 30, 30, 30,365,365,365,365,365,

365,365,365,365,365,365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,

4' ET Cover, Soil No. 1

Wasatch Landfill (4 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

```
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,45,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.4,
2,31.7,2,39.0,2,46.3,2,53.6,
2,60.9,2,68.2,2,75.5,2,82.8,
2,90.1,2,97.4,2,104.7,2,110.5,
2,114.3,2,116.9,2,118.6,2,119.7,
2,120.5,2,121.0,2,121.3,2,121.5,
2,121.7,2,121.8,2,121.9,3,122.0,
3,122.2,3,122.7,3,123.5,3,124.8,
3,126.9,3,130.1,3,135.1,3,140.1,
3,145.1,
Surface Layer Moistre Characteristics
0.4860,0.0000,0.0315,1.0967,
Surface Layer Hydraulic Conductivity
2,0.3600,0.0315,1.0967,-1.0,
Weathered Clay w/ Silt Moisture Characteristics
0.4860,0.0000,0.0315,1.0967,
Weathered Clay w/ Silt Hydraulic Conductivity
2,0.0540,0.0315,1.0967,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0,2365.0,
2365.0,2365.0,2365.0, 100.0,
 100.0, 100.0, 100.0, 100.0,
 100.0, 100.0, 100.0, 100.0,
 100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,
```

```
1.163,0.129,0.02,
  1,  1,  1,  1,  1,  7,  8,  9, 10, 14,
 17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
 30,365,365,365,365,365,365,365,365,365,
365,365,365,365,365,365,365,365,365,365,
365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,
```

4' ET Cover, Soil No. 2

Wasatch Landfill (4 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
1,1,
365,1,365,
1,5,1,0,1,
0,24.0,
0,2,1,0.001,
0.15,0.0000001,0.0,
2.0,0.000001,0.0,0.0,0.0,
4,3,0.0,
0,1,2,1,
0.0,1.0E+6,0.0,0.99,
0,0,0,
0,0.0,
0,0.0,0.0,0.0,0,
0,0,0.0,
0,0.0,0.0,0.0,
0,0.0,0.0,
1,0.66,294.43,0.24,
3,45,
1, 0.1,1, 0.3,1, 0.5,1, 0.8,
1, 1.3,2, 2.1,2, 3.2,2, 4.9,
2, 7.5,2,11.3,2,17.1,2,24.4,
2,31.7,2,39.0,2,46.3,2,53.6,
2,60.9,2,68.2,2,75.5,2,82.8,
2,90.1,2,97.4,2,104.7,2,110.5,
2,114.3,2,116.9,2,118.6,2,119.7,
2,120.5,2,121.0,2,121.3,2,121.5,
2,121.7,2,121.8,2,121.9,3,122.0,
3,122.2,3,122.7,3,123.5,3,124.8,
3,126.9,3,130.1,3,135.1,3,140.1,
3,145.1,
Surface Layer (Lean Clay) Moistre Characteristics
0.4548,0.0000,0.0110,1.1535,
Surface Layer (Lean Clay) Hydraulic Conductivity
2,0.3600,0.0110,1.1535,-1.0,
Lean Clay Moisture Characteristics
0.4548,0.0000,0.0110,1.1535,
Lean Clay Hydraulic Conductivity
2,0.0209,0.0110,1.1535,-1.0,
MSW Moisture Characteristics
0.5300,0.1100,0.2600,2.2200,
MSW Hydraulic Conductivity
2,3.6000,0.2600,2.2200,0.5,
0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0,1150.0,
1150.0,1150.0,1150.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0,
100.0,
1,1,1,1,117,289,
0.0,
4,
116,0.0,176,1.00,259,1.00,289,0.0,

```
1.163,0.129,0.02,
  1,  1,  1,  1,  1,  7,  8,  9, 10, 14,
 17, 20, 23, 26, 29, 30, 30, 30, 30, 30,
 30,365,365,365,365,365,365,365,365,365,
365,365,365,365,365,365,365,365,365,365,
365,365,365,365,365,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
15000.0,333.0,30.0,
0.0,0.52,0.5,0.0,3.7,
```

Annual Potential Evapotranspiration Input

0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.508,0.508,0.610,0.610,0.635,0.686,
0.762,0.279,0.279,0.508,0.584,0.533,0.762,0.660,
0.610,0.762,0.889,0.330,0.610,0.762,0.635,0.711,
0.457,0.381,0.686,0.787,0.635,0.660,0.025,0.305,
0.838,0.762,0.737,0.889,0.914,0.762,1.473,0.940,
0.635,0.762,0.686,0.889,0.889,0.737,0.533,0.711,
0.889,1.092,0.889,0.711,0.660,0.991,1.092,1.829,
0.406,0.838,0.406,0.864,0.584,0.381,0.787,0.686,
0.635,0.737,0.864,1.118,0.991,0.838,1.016,0.965,
1.219,0.838,0.838,0.864,0.940,0.914,0.762,0.914,
1.524,1.499,1.041,1.041,1.295,1.524,1.524,1.372,
1.422,1.651,1.346,1.194,1.626,1.524,1.524,1.803,
1.143,1.448,2.007,1.422,1.245,0.838,1.143,0.965,
1.295,1.422,0.762,1.194,1.473,1.397,1.245,0.965,
0.762,1.245,1.143,1.270,1.549,1.168,1.219,0.965,
0.991,1.270,1.473,1.346,1.448,0.889,1.067,1.143,
1.245,1.397,1.194,1.219,1.397,0.991,0.991,0.965,
0.864,1.270,1.295,0.914,0.305,0.610,1.219,0.889,
0.940,0.686,0.813,0.914,0.838,1.626,1.778,1.143,
0.864,1.219,1.143,0.838,1.168,0.940,1.016,0.711,
0.711,0.889,0.838,0.914,1.041,0.787,0.914,0.940,
0.940,1.067,0.940,0.864,0.838,0.356,0.533,0.406,
0.660,0.711,0.686,0.381,0.940,0.508,0.559,0.406,
0.635,0.508,0.686,0.940,0.457,1.219,0.635,0.508,
0.432,0.381,0.457,0.508,0.533,0.432,0.483,0.432,
0.508,0.381,0.356,0.152,0.279,0.229,0.356,0.152,
0.229,0.254,0.254,0.330,0.279,0.559,0.584,0.686,
0.660,0.940,0.305,0.279,0.356,0.102,0.229,0.127,
0.152,0.305,0.178,0.127,0.152,0.178,0.305,0.229,
0.178,0.051,0.102,0.152,0.025,0.000,0.076,0.051,
0.076,0.330,0.102,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,
0.000,0.000,0.000,0.000,0.000,0.000,

Annual Precipitation Input

91, NWATER (Total for Syn. Year = 42.5 cm)
1,1,2,1.0000,
0.0,0.127,
24.0,0.0000,
6,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
20,1,2,1.0000,
0.0,0.1778,
24.0,0.0000,
21,1,2,1.0000,
0.0,0.381,
24.0,0.0000,
25,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
27,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
28,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
34,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
39,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
40,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
45,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
46,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
47,1,2,1.0000,
0.0,0.508,
24.0,0.0000,
48,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
54,1,2,1.0000,
0.0,0.254,
24.0,0.0000,
57,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
61,1,2,1.0000,
0.0,0.1524,
24.0,0.0000,
62,1,2,1.0000,
0.0,1.3716,
24.0,0.0000,
63,1,2,1.0000,
0.0,0.2032,
24.0,0.0000,
64,1,2,1.0000,
0.0,0.0508,

24.0,0.0000,
69,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
70,1,2,1.0000,
0.0,0.254,
24.0,0.0000,
71,1,2,1.0000,
0.0,0.1524,
24.0,0.0000,
73,1,2,1.0000,
0.0,0.2794,
24.0,0.0000,
74,1,2,1.0000,
0.0,0.6858,
24.0,0.0000,
75,1,2,1.0000,
0.0,0.4572,
24.0,0.0000,
77,1,2,1.0000,
0.0,0.254,
24.0,0.0000,
85,1,2,1.0000,
0.0,0.3302,
24.0,0.0000,
86,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
87,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
88,1,2,1.0000,
0.0,0.381,
24.0,0.0000,
89,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
91,1,2,1.0000,
0.0,1.397,
24.0,0.0000,
92,1,2,1.0000,
0.0,0.0762,
24.0,0.0000,
94,1,2,1.0000,
0.0,0.127,
24.0,0.0000,
96,1,2,1.0000,
0.0,0.381,
24.0,0.0000,
102,1,2,1.0000,
0.0,0.254,
24.0,0.0000,
109,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
119,1,2,1.0000,
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24.0,0.0000,
123,1,2,1.0000,
0.0,0.2794,

24.0,0.0000,
128,1,2,1.0000,
0.0,0.1778,
24.0,0.0000,
129,1,2,1.0000,
0.0,1.1684,
24.0,0.0000,
130,1,2,1.0000,
0.0,1.0922,
24.0,0.0000,
131,1,2,1.0000,
0.0,0.254,
24.0,0.0000,
138,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
139,1,2,1.0000,
0.0,0.1778,
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148,1,2,1.0000,
0.0,1.3208,
24.0,0.0000,
152,1,2,1.0000,
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24.0,0.0000,
156,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
166,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
173,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
175,1,2,1.0000,
0.0,0.1016,
24.0,0.0000,
181,1,2,1.0000,
0.0,0.3556,
24.0,0.0000,
185,1,2,1.0000,
0.0,0.1524,
24.0,0.0000,
186,1,2,1.0000,
0.0,1.8034,
24.0,0.0000,
187,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
189,1,2,1.0000,
0.0,1.27,
24.0,0.0000,
204,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
208,1,2,1.0000,
0.0,0.5588,
24.0,0.0000,
209,1,2,1.0000,
0.0,0.9144,

24.0,0.0000,
226,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
229,1,2,1.0000,
0.0,0.1778,
24.0,0.0000,
238,1,2,1.0000,
0.0,1.7018,
24.0,0.0000,
239,1,2,1.0000,
0.0,0.8636,
24.0,0.0000,
240,1,2,1.0000,
0.0,0.127,
24.0,0.0000,
253,1,2,1.0000,
0.0,1.143,
24.0,0.0000,
254,1,2,1.0000,
0.0,0.889,
24.0,0.0000,
255,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
256,1,2,1.0000,
0.0,0.5842,
24.0,0.0000,
257,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
258,1,2,1.0000,
0.0,0.1524,
24.0,0.0000,
260,1,2,1.0000,
0.0,0.1016,
24.0,0.0000,
268,1,2,1.0000,
0.0,0.508,
24.0,0.0000,
269,1,2,1.0000,
0.0,4.4196,
24.0,0.0000,
270,1,2,1.0000,
0.0,1.2954,
24.0,0.0000,
271,1,2,1.0000,
0.0,0.6604,
24.0,0.0000,
272,1,2,1.0000,
0.0,1.143,
24.0,0.0000,
273,1,2,1.0000,
0.0,0.508,
24.0,0.0000,
274,1,2,1.0000,
0.0,0.0762,
24.0,0.0000,
280,1,2,1.0000,
0.0,0.1016,

24.0,0.0000,
298,1,2,1.0000,
0.0,0.2032,
24.0,0.0000,
299,1,2,1.0000,
0.0,1.9558,
24.0,0.0000,
300,1,2,1.0000,
0.0,0.0508,
24.0,0.0000,
302,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
303,1,2,1.0000,
0.0,0.2032,
24.0,0.0000,
304,1,2,1.0000,
0.0,0.381,
24.0,0.0000,
323,1,2,1.0000,
0.0,0.762,
24.0,0.0000,
332,1,2,1.0000,
0.0,0.0254,
24.0,0.0000,
334,1,2,1.0000,
0.0,1.8288,
24.0,0.0000,
335,1,2,1.0000,
0.0,1.8542,
24.0,0.0000,
341,1,2,1.0000,
0.0,1.1938,
24.0,0.0000,

APPENDIX D
UNSAT-H OUTPUT FILES

2' ET Cover, Soil No. 1

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\2'\2'-S1.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\2'\2'-S10005.re
Date of Run: 23 May 2006
Time of Run: 13:46:47.02
Title:
Wasatch Landfill (2 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	3.478E+01	0.4551	294.43	2	3.000E-01	3.458E+01	0.4553	294.43
3	5.000E-01	3.438E+01	0.4554	294.43	4	8.000E-01	3.408E+01	0.4556	294.43
5	1.300E+00	3.359E+01	0.4559	294.43	6	7.100E+00	2.858E+01	0.4595	294.43
7	1.290E+01	2.718E+01	0.4605	294.43	8	1.870E+01	2.860E+01	0.4594	294.43
9	2.450E+01	3.511E+01	0.4549	294.43	10	3.050E+01	5.799E+01	0.4420	294.43
11	3.650E+01	2.605E+02	0.3932	294.43	12	4.230E+01	1.010E+03	0.3471	294.43
13	4.810E+01	8.501E+02	0.3528	294.43	14	5.390E+01	6.636E+02	0.3611	294.43
15	5.970E+01	5.514E+02	0.3674	294.43	16	6.020E+01	5.446E+02	0.3678	294.43
17	6.050E+01	5.407E+02	0.3680	294.43	18	6.070E+01	5.382E+02	0.3682	294.43
19	6.090E+01	5.357E+02	0.3684	294.43	20	6.100E+01	5.345E+02	0.3684	294.43
21	6.110E+01	4.121E+02	0.1114	294.43	22	6.130E+01	7.844E+01	0.1206	294.43
23	6.150E+01	7.133E+01	0.1219	294.43	24	6.180E+01	6.477E+01	0.1234	294.43
25	6.230E+01	5.824E+01	0.1252	294.43	26	6.310E+01	5.221E+01	0.1274	294.43
27	6.890E+01	3.822E+01	0.1354	294.43	28	7.470E+01	3.356E+01	0.1398	294.43
29	8.050E+01	3.116E+01	0.1426	294.43	30	8.630E+01	3.033E+01	0.1436	294.43

Initial Water Storage = 28.7029 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

Node Number = 20
Depth (cm) = 61.00000
Water (cm3/cm3) = 0.36842
Head (cm) = 5.34801E+02
LiqWater Flow (cm)=-2.37342E-04
IsoVapor Flow (cm)=-4.97985E-05
Plant Sink (cm) = 0.00000E+00

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
28.7029+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0008 =	28.8291 vs.	28.8291

Mass Balance = 2.6783E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm
Transpiration: Potential = 0.0000 cm, Actual = 0.0000 cm

```
DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
-------------
Node Number          =      20
Depth (cm)           =    61.00000
Water (cm3/cm3)      =     0.36844
Head (cm)            = 5.34461E+02
LiqWater Flow (cm)=-2.38452E-04
IsoVapor Flow (cm)=-4.98488E-05
Plant Sink (cm)      = 0.00000E+00

                                                    LIQUID
 PRESTOR    INFIL  RUNOFF    EVAPO   TRANS    DRAIN     NEWSTOR       STORAGE
 28.8266+ 0.0000+ 0.0000 - 0.0000- 0.0000-  0.0008 =   28.8259 vs.   28.8259

Mass Balance = -1.4152E-08 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1
```

UNSAT-H Version 3.01
SIMULATION SUMMARY

Title:
Wasatch Landfill (2 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

Transpiration Scheme is:	=	1	
Potential Evapotranspiration	=	1.9154E+02	[cm]
Potential Transpiration	=	7.5007E+01	[cm]
Actual Transpiration	=	1.6374E+01	[cm]
Potential Evaporation	=	1.1663E+02	[cm]
Actual Evaporation	=	1.3404E+01	[cm]
Evaporation during Growth	=	8.4256E+00	[cm]
Total Runoff	=	8.9776E+00	[cm]
Total Infiltration	=	3.3548E+01	[cm]
Total Basal Liquid Flux (drainage)	=	3.3656E+00	[cm]
Total Basal Vapor Flux (temp-grad)	=	0.0000E+00	[cm]
Total Applied Water	=	4.2520E+01	[cm]
Actual Rainfall	=	4.2520E+01	[cm]
Actual Irrigation	=	0.0000E+00	[cm]
Total Final Moisture Storage	=	2.8826E+01	[cm]
Mass Balance Error	=	2.8131E-01	[cm]
Total Successful Time Steps	=	77360	
Total Attempted Time Steps	=	93635	
Total Time Step Reductions (DHMAX)	=	0	
Total Changes in Surface Boundary	=	28377	
Total Time Actually Simulated	=	3.6500E+02	[days]

Total liquid water flow (cm) across different depths at the end of 3.6500E+02 days:

DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW
0.100	2.0144E+01	0.200	2.7745E+01	0.400	2.5594E+01
0.650	2.3839E+01	1.050	2.1865E+01	4.200	1.6848E+01
10.000	1.1773E+01	15.800	1.0024E+01	21.600	8.8361E+00
27.500	7.6263E+00	33.500	6.5877E+00	39.400	5.7633E+00
45.200	5.0791E+00	51.000	4.4662E+00	56.800	3.9063E+00

59.950	3.5237E+00	60.350	3.4544E+00	60.600	3.4081E+00
60.800	3.3871E+00	60.950	3.3743E+00	61.050	3.3755E+00
61.200	3.3911E+00	61.400	3.3663E+00	61.650	3.3660E+00
62.050	3.3659E+00	62.700	3.3658E+00	66.000	3.3657E+00
71.800	3.3657E+00	77.600	3.3657E+00	83.400	3.3657E+00
86.300	3.3656E+00				

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	6.6665E-02	0.500	1.2488E-01
0.800	2.7333E-01	1.300	2.9105E+00	7.100	4.8457E+00
12.900	1.7540E+00	18.700	1.2125E+00	24.500	1.1995E+00
30.500	9.7821E-01	36.500	7.9705E-01	42.300	6.7264E-01
48.100	6.1049E-01	53.900	5.6039E-01	59.700	2.7380E-01
60.200	3.4421E-02	60.500	2.1434E-02	60.700	1.7122E-02
60.900	1.2796E-02	61.000	8.5144E-03	61.100	0.0000E+00
61.300	0.0000E+00	61.500	0.0000E+00	61.800	0.0000E+00
62.300	0.0000E+00	63.100	0.0000E+00	68.900	0.0000E+00
74.700	0.0000E+00	80.500	0.0000E+00	86.300	0.0000E+00

2’ ET Cover, Soil No. 2

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\2'\2'-S2.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\2'\2'-S20005.re
Date of Run: 23 May 2006
Time of Run: 13:49:44.33
Title:
Wasatch Landfill (2 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)

NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	1.010E+02	0.4113	294.43	2	3.000E-01	1.008E+02	0.4113	294.43
3	5.000E-01	1.006E+02	0.4114	294.43	4	8.000E-01	1.003E+02	0.4115	294.43
5	1.300E+00	9.984E+01	0.4117	294.43	6	7.100E+00	9.508E+01	0.4133	294.43
7	1.290E+01	9.982E+01	0.4117	294.43	8	1.870E+01	1.130E+02	0.4074	294.43
9	2.450E+01	1.404E+02	0.3995	294.43	10	3.050E+01	2.007E+02	0.3851	294.43
11	3.650E+01	3.491E+02	0.3606	294.43	12	4.230E+01	6.998E+02	0.3285	294.43
13	4.810E+01	1.043E+03	0.3103	294.43	14	5.390E+01	1.112E+03	0.3074	294.43
15	5.970E+01	1.077E+03	0.3089	294.43	16	6.020E+01	1.073E+03	0.3090	294.43
17	6.050E+01	1.071E+03	0.3091	294.43	18	6.070E+01	1.069E+03	0.3092	294.43
19	6.090E+01	1.068E+03	0.3093	294.43	20	6.100E+01	1.067E+03	0.3093	294.43
21	6.110E+01	7.639E+02	0.1107	294.43	22	6.130E+01	9.649E+01	0.1182	294.43
23	6.150E+01	8.063E+01	0.1203	294.43	24	6.180E+01	7.014E+01	0.1221	294.43
25	6.230E+01	6.149E+01	0.1243	294.43	26	6.310E+01	5.437E+01	0.1266	294.43
27	6.890E+01	3.962E+01	0.1343	294.43	28	7.470E+01	3.484E+01	0.1384	294.43
29	8.050E+01	3.238E+01	0.1411	294.43	30	8.630E+01	3.154E+01	0.1421	294.43

Initial Water Storage = 25.8615 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

```
Node Number          =       1          20
Depth (cm)           =     0.10000    61.00000
Water (cm3/cm3)      =     0.42681     0.30932
Head (cm)            = 5.93717E+01 1.06624E+03
LiqWater Flow (cm)= 1.25447E-01-1.57200E-04
IsoVapor Flow (cm)= 1.97714E-09-1.37056E-04
Plant Sink (cm)      = 0.00000E+00 0.00000E+00
```

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
25.8615+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0006 =	25.9879 vs.	25.9879

Mass Balance = 2.4587E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm
Transpiration: Potential = 0.0000 cm, Actual = 0.0000 cm

```
DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
--------------
Node Number          =        1          20
Depth (cm)           =     0.10000    61.00000
Water (cm3/cm3)      =     0.41128     0.30930
Head (cm)            = 1.01036E+02 1.06672E+03
LiqWater Flow (cm)= 7.03061E-05-1.57708E-04
IsoVapor Flow (cm)=-7.91158E-09-1.37412E-04
Plant Sink (cm)      = 0.00000E+00 0.00000E+00

                                                    LIQUID
  PRESTOR    INFIL  RUNOFF     EVAPO    TRANS     DRAIN      NEWSTOR        STORAGE
  25.8621+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0006 =    25.8615 vs.    25.8615

Mass Balance = -1.2115E-08 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1
```

UNSAT-H Version 3.01
SIMULATION SUMMARY

Title:
Wasatch Landfill (2 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)

Transpiration Scheme is:	=	1	
Potential Evapotranspiration	=	1.9154E+02	[cm]
Potential Transpiration	=	7.5007E+01	[cm]
Actual Transpiration	=	1.5243E+01	[cm]
Potential Evaporation	=	1.1663E+02	[cm]
Actual Evaporation	=	1.9386E+01	[cm]
Evaporation during Growth	=	1.2370E+01	[cm]
Total Runoff	=	6.5961E+00	[cm]
Total Infiltration	=	3.5924E+01	[cm]
Total Basal Liquid Flux (drainage)	=	1.3702E+00	[cm]
Total Basal Vapor Flux (temp-grad)	=	0.0000E+00	[cm]
Total Applied Water	=	4.2520E+01	[cm]
Actual Rainfall	=	4.2520E+01	[cm]
Actual Irrigation	=	0.0000E+00	[cm]
Total Final Moisture Storage	=	2.5862E+01	[cm]
Mass Balance Error	=	-7.4344E-02	[cm]
Total Successful Time Steps	=	60210	
Total Attempted Time Steps	=	60802	
Total Time Step Reductions (DHMAX)	=	0	
Total Changes in Surface Boundary	=	23902	
Total Time Actually Simulated	=	3.6500E+02	[days]

Total liquid water flow (cm) across different depths at the end of 3.6500E+02 days:

DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW
0.100	1.6539E+01	0.200	2.5169E+01	0.400	2.2346E+01
0.650	2.0306E+01	1.050	1.8106E+01	4.200	1.4756E+01
10.000	1.0164E+01	15.800	8.0722E+00	21.600	6.5536E+00
27.500	5.3011E+00	33.500	4.3415E+00	39.400	3.5840E+00
45.200	2.9406E+00	51.000	2.3515E+00	56.800	1.7761E+00

59.950	1.4730E+00	60.350	1.4355E+00	60.600	1.4122E+00
60.800	1.3936E+00	60.950	1.3796E+00	61.050	1.3949E+00
61.200	1.4230E+00	61.400	1.3716E+00	61.650	1.3708E+00
62.050	1.3705E+00	62.700	1.3704E+00	66.000	1.3703E+00
71.800	1.3702E+00	77.600	1.3702E+00	83.400	1.3702E+00
86.300	1.3702E+00				

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	6.4993E-02	0.500	9.5667E-02
0.800	1.8041E-01	1.300	1.6966E+00	7.100	4.3598E+00
12.900	2.0940E+00	18.700	1.5253E+00	24.500	1.2626E+00
30.500	9.6839E-01	36.500	7.6248E-01	42.300	6.5090E-01
48.100	5.9934E-01	53.900	5.7630E-01	59.700	3.0318E-01
60.200	3.7530E-02	60.500	2.3292E-02	60.700	1.8628E-02
60.900	1.3966E-02	61.000	9.3095E-03	61.100	0.0000E+00
61.300	0.0000E+00	61.500	0.0000E+00	61.800	0.0000E+00
62.300	0.0000E+00	63.100	0.0000E+00	68.900	0.0000E+00
74.700	0.0000E+00	80.500	0.0000E+00	86.300	0.0000E+00

2.5' ET Cover, Soil No. 1

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\2.5'\2.5'-S1.in
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\2.5'\2.5'-S1000
Date of Run: 31 May 2006
Time of Run: 18:21:34.43
Title:
Wasatch Landfill (2.5 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	3.319E+01	0.4562	294.43	2	3.000E-01	3.299E+01	0.4563	294.43
3	5.000E-01	3.279E+01	0.4565	294.43	4	8.000E-01	3.249E+01	0.4567	294.43
5	1.300E+00	3.200E+01	0.4570	294.43	6	2.100E+00	3.124E+01	0.4575	294.43
7	3.200E+00	3.037E+01	0.4582	294.43	8	4.900E+00	2.921E+01	0.4590	294.43
9	7.500E+00	2.782E+01	0.4600	294.43	10	1.130E+01	2.658E+01	0.4609	294.43
11	1.710E+01	2.664E+01	0.4609	294.43	12	2.410E+01	3.157E+01	0.4573	294.43
13	3.110E+01	5.155E+01	0.4452	294.43	14	3.810E+01	2.471E+02	0.3950	294.43
15	4.510E+01	5.159E+02	0.3696	294.43	16	5.210E+01	3.241E+02	0.3856	294.43
17	5.910E+01	2.140E+02	0.4000	294.43	18	6.490E+01	1.680E+02	0.4083	294.43
19	6.870E+01	1.493E+02	0.4123	294.43	20	7.130E+01	1.400E+02	0.4144	294.43
21	7.300E+01	1.351E+02	0.4156	294.43	22	7.410E+01	1.324E+02	0.4163	294.43
23	7.490E+01	1.306E+02	0.4168	294.43	24	7.540E+01	1.295E+02	0.4170	294.43
25	7.570E+01	1.290E+02	0.4172	294.43	26	7.590E+01	1.286E+02	0.4173	294.43
27	7.610E+01	1.282E+02	0.4174	294.43	28	7.620E+01	1.280E+02	0.4174	294.43
29	7.640E+01	1.236E+02	0.1161	294.43	30	7.660E+01	8.382E+01	0.1198	294.43
31	7.690E+01	6.942E+01	0.1223	294.43	32	7.740E+01	5.932E+01	0.1249	294.43
33	7.820E+01	5.164E+01	0.1276	294.43	34	8.400E+01	3.643E+01	0.1369	294.43
35	8.980E+01	3.173E+01	0.1418	294.43	36	9.560E+01	2.911E+01	0.1453	294.43
37	1.014E+02	2.752E+01	0.1478	294.43	38	1.072E+02	2.693E+01	0.1488	294.43

Initial Water Storage = 36.6091 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

Node Number =	1	28
Depth (cm) =	0.10000	76.20000
Water (cm3/cm3) =	0.47964	0.41732
Head (cm) =	6.00979E+00	1.28373E+02
LiqWater Flow (cm)=	1.24655E-01	-3.54697E-04
IsoVapor Flow (cm)=	1.65877E-09	-6.85578E-07
Plant Sink (cm) =	0.00000E+00	0.00000E+00

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
36.6091+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0014 =	36.7348 vs.	36.7347

Mass Balance = 2.7707E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm
Transpiration: Potential = 0.0000 cm, Actual = 0.0000 cm

```
DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
-------------
Node Number        =       1          28
Depth (cm)         =     0.10000    76.20000
Water (cm3/cm3)    =     0.45616     0.41742
Head (cm)          = 3.32337E+01 1.28002E+02
LiqWater Flow (cm)= 4.22652E-05-3.56997E-04
IsoVapor Flow (cm)=-5.41954E-09-6.82760E-07
Plant Sink (cm)    = 0.00000E+00 0.00000E+00

                                              LIQUID
 PRESTOR    INFIL  RUNOFF     EVAPO    TRANS    DRAIN      NEWSTOR       STORAGE
 36.5948+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0014 =    36.5934 vs.   36.5934

Mass Balance = -2.5621E-08 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1
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UNSAT-H Version 3.01
SIMULATION SUMMARY

Title:
Wasatch Landfill (2.5 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

```
Transpiration Scheme is:              =    1
Potential Evapotranspiration          =  1.9154E+02     [cm]
Potential Transpiration               =  7.5007E+01     [cm]
Actual Transpiration                  =  1.7032E+01     [cm]
Potential Evaporation                 =  1.1663E+02     [cm]
Actual Evaporation                    =  1.1420E+01     [cm]
Evaporation during Growth             =  7.2333E+00     [cm]
Total Runoff                          =  1.0077E+01     [cm]
Total Infiltration                    =  3.2463E+01     [cm]
Total Basal Liquid Flux (drainage)    =  3.1745E+00     [cm]
Total Basal Vapor Flux (temp-grad)    =  0.0000E+00     [cm]
Total Applied Water                   =  4.2520E+01     [cm]
Actual Rainfall                       =  4.2520E+01     [cm]
Actual Irrigation                     =  0.0000E+00     [cm]
Total Final Moisture Storage          =  3.6593E+01     [cm]
Mass Balance Error                    =  8.5162E-01     [cm]
Total Successful Time Steps           =     76692
Total Attempted Time Steps            =     91752
Total Time Step Reductions (DHMAX)    =         0
Total Changes in Surface Boundary     =     32039
Total Time Actually Simulated         =  3.6500E+02     [days]
```

Total liquid water flow (cm) across different depths at the end of 3.6500E+02 days:

DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW
0.100	2.1043E+01	0.200	2.7950E+01	0.400	2.5904E+01

0.650	2.4420E+01	1.050	2.2798E+01	1.700	2.1056E+01
2.650	1.9090E+01	4.050	1.6707E+01	6.200	1.4096E+01
9.400	1.1724E+01	14.200	1.0067E+01	20.600	8.6323E+00
27.600	7.2205E+00	34.600	6.1396E+00	41.600	5.3128E+00
48.600	4.6181E+00	55.600	4.0095E+00	62.000	3.5173E+00
66.800	3.1990E+00	70.000	3.2266E+00	72.150	3.2342E+00
73.550	3.2188E+00	74.500	3.2076E+00	75.150	3.1954E+00
75.550	3.1882E+00	75.800	3.1779E+00	76.000	3.1745E+00
76.150	3.1745E+00	76.300	3.1746E+00	76.500	3.1770E+00
76.750	3.1752E+00	77.150	3.1748E+00	77.800	3.1747E+00
81.100	3.1746E+00	86.900	3.1745E+00	92.700	3.1745E+00
98.500	3.1745E+00	104.300	3.1745E+00	107.200	3.1745E+00

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	6.0486E-02	0.500	1.2452E-01
0.800	2.6682E-01	1.300	5.6319E-01	2.100	1.0824E+00
3.200	1.6688E+00	4.900	2.3735E+00	7.500	2.3755E+00
11.300	1.6991E+00	17.100	1.3892E+00	24.100	1.3850E+00
31.100	1.0700E+00	38.100	8.3149E-01	45.100	6.9834E-01
52.100	6.1151E-01	59.100	4.9246E-01	64.900	3.4008E-01
68.700	0.0000E+00	71.300	0.0000E+00	73.000	0.0000E+00
74.100	0.0000E+00	74.900	0.0000E+00	75.400	0.0000E+00
75.700	0.0000E+00	75.900	0.0000E+00	76.100	0.0000E+00
76.200	0.0000E+00	76.400	0.0000E+00	76.600	0.0000E+00
76.900	0.0000E+00	77.400	0.0000E+00	78.200	0.0000E+00
84.000	0.0000E+00	89.800	0.0000E+00	95.600	0.0000E+00
101.400	0.0000E+00	107.200	0.0000E+00		

2.5' ET Cover, Soil No. 2

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\2.5'\2.5'-S2.in
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\2.5'\2.5'-S2000
Date of Run: 02 Jun 2006
Time of Run: 10:25:04.12
Title:
Wasatch Landfill (2.5 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)

NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	1.261E+02	0.4035	294.43	2	3.000E-01	1.259E+02	0.4035	294.43
3	5.000E-01	1.257E+02	0.4036	294.43	4	8.000E-01	1.254E+02	0.4037	294.43
5	1.300E+00	1.249E+02	0.4038	294.43	6	2.100E+00	1.242E+02	0.4040	294.43
7	3.200E+00	1.240E+02	0.4041	294.43	8	4.900E+00	1.243E+02	0.4040	294.43
9	7.500E+00	1.266E+02	0.4033	294.43	10	1.130E+01	1.345E+02	0.4011	294.43
11	1.710E+01	1.612E+02	0.3941	294.43	12	2.410E+01	2.458E+02	0.3763	294.43
13	3.110E+01	5.732E+02	0.3377	294.43	14	3.810E+01	1.277E+03	0.3013	294.43
15	4.510E+01	1.229E+03	0.3030	294.43	16	5.210E+01	9.748E+02	0.3134	294.43
17	5.910E+01	8.021E+02	0.3222	294.43	18	6.490E+01	7.161E+02	0.3274	294.43
19	6.870E+01	6.808E+02	0.3298	294.43	20	7.130E+01	6.645E+02	0.3309	294.43
21	7.300E+01	6.569E+02	0.3314	294.43	22	7.410E+01	6.533E+02	0.3317	294.43
23	7.490E+01	6.512E+02	0.3318	294.43	24	7.540E+01	6.502E+02	0.3319	294.43
25	7.570E+01	6.497E+02	0.3319	294.43	26	7.590E+01	6.494E+02	0.3319	294.43
27	7.610E+01	6.491E+02	0.3320	294.43	28	7.620E+01	6.490E+02	0.3320	294.43
29	7.640E+01	6.312E+02	0.1108	294.43	30	7.660E+01	5.905E+02	0.1109	294.43
31	7.690E+01	5.316E+02	0.1110	294.43	32	7.740E+01	4.402E+02	0.1113	294.43
33	7.820E+01	3.177E+02	0.1119	294.43	34	8.400E+01	1.149E+02	0.1167	294.43
35	8.980E+01	1.037E+02	0.1175	294.43	36	9.560E+01	1.009E+02	0.1178	294.43
37	1.014E+02	1.002E+02	0.1179	294.43	38	1.072E+02	1.001E+02	0.1179	294.43

Initial Water Storage = 30.0043 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day =   1, Simulated Time = 24.0000 hr

Node Number   =   28
Depth (cm)   =   76.20000
Water (cm3/cm3)   =   0.33187
Head (cm)   = 6.50275E+02
LiqWater Flow (cm)=-1.23714E-05
IsoVapor Flow (cm)=-3.71417E-06
Plant Sink (cm)   = 0.00000E+00

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
30.0043+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0000 =	30.1313 vs.	30.1313

Mass Balance = 2.6626E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm
Transpiration: Potential = 0.0000 cm, Actual = 0.0000 cm

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 DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
 -------------
 Node Number        =      28
 Depth (cm)         =    76.20000
 Water (cm3/cm3)    =     0.33395
 Head (cm)          = 6.21750E+02
 LiqWater Flow (cm)=-1.36532E-05
 IsoVapor Flow (cm)=-3.47206E-06
 Plant Sink (cm)    = 0.00000E+00

                                                 LIQUID
  PRESTOR    INFIL  RUNOFF    EVAPO   TRANS      DRAIN      NEWSTOR      STORAGE
  30.1110+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0000 =   30.1110 vs.   30.1110

 Mass Balance = -6.6280E-10 cm;  Time step attempts =  160 and successes =  160
   Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
 Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1

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                              UNSAT-H Version 3.01
                               SIMULATION SUMMARY

 Title:
 Wasatch Landfill (2.5 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
--------------------------------------------------------------------------------

 Transpiration Scheme is:             =    1
 Potential Evapotranspiration         =  1.9154E+02     [cm]
 Potential Transpiration              =  7.5007E+01     [cm]
 Actual Transpiration                 =  1.6467E+01     [cm]
 Potential Evaporation                =  1.1663E+02     [cm]
 Actual Evaporation                   =  1.5438E+01     [cm]
 Evaporation during Growth            =  9.8995E+00     [cm]
 Total Runoff                         =  1.0758E+01     [cm]
 Total Infiltration                   =  3.1761E+01     [cm]
 Total Basal Liquid Flux (drainage)   =  6.7693E-04     [cm]
 Total Basal Vapor Flux (temp-grad)   =  0.0000E+00     [cm]
 Total Applied Water                  =  4.2520E+01     [cm]
 Actual Rainfall                      =  4.2520E+01     [cm]
 Actual Irrigation                    =  0.0000E+00     [cm]
 Total Final Moisture Storage         =  3.0111E+01     [cm]
 Mass Balance Error                   = -2.5064E-01     [cm]
 Total Successful Time Steps          =     59981
 Total Attempted Time Steps           =     60411
 Total Time Step Reductions (DHMAX)   =         0
 Total Changes in Surface Boundary    =     27054
 Total Time Actually Simulated        =  3.6500E+02     [days]


 Total liquid water flow (cm) across different depths at the end of 3.6500E+02
days:

    DEPTH         FLOW        DEPTH        FLOW        DEPTH        FLOW
   --------   -----------   --------   -----------   --------   -----------
      0.100   1.6323E+01      0.200    2.3804E+01       0.400   2.1652E+01
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0.650	2.0114E+01	1.050	1.8581E+01	1.700	1.7316E+01
2.650	1.5879E+01	4.050	1.4000E+01	6.200	1.1619E+01
9.400	9.2322E+00	14.200	7.3924E+00	20.600	5.7510E+00
27.600	4.3946E+00	34.600	3.3797E+00	41.600	2.5494E+00
48.600	1.8333E+00	55.600	1.1381E+00	62.000	5.0256E-01
66.800	1.8189E-02	70.000	1.1787E-02	72.150	7.5166E-03
73.550	4.7432E-03	74.500	2.8627E-03	75.150	1.5760E-03
75.550	7.8391E-04	75.800	2.8875E-04	76.000	-1.0748E-04
76.150	-4.0473E-04	76.300	8.1435E-06	76.500	2.9354E-03
76.750	2.0103E-03	77.150	9.4413E-04	77.800	1.4896E-04
81.100	-8.4420E-04	86.900	-4.5024E-04	92.700	2.5302E-04
98.500	5.5491E-04	104.300	6.5423E-04	107.200	6.7693E-04

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	5.2790E-02	0.500	7.9087E-02
0.800	1.5001E-01	1.300	2.8310E-01	2.100	6.4724E-01
3.200	1.4298E+00	4.900	2.2403E+00	7.500	2.3790E+00
11.300	1.8843E+00	17.100	1.6534E+00	24.100	1.3485E+00
31.100	1.0088E+00	38.100	8.1495E-01	45.100	7.1944E-01
52.100	6.7942E-01	59.100	6.2204E-01	64.900	4.7462E-01
68.700	0.0000E+00	71.300	0.0000E+00	73.000	0.0000E+00
74.100	0.0000E+00	74.900	0.0000E+00	75.400	0.0000E+00
75.700	0.0000E+00	75.900	0.0000E+00	76.100	0.0000E+00
76.200	0.0000E+00	76.400	0.0000E+00	76.600	0.0000E+00
76.900	0.0000E+00	77.400	0.0000E+00	78.200	0.0000E+00
84.000	0.0000E+00	89.800	0.0000E+00	95.600	0.0000E+00
101.400	0.0000E+00	107.200	0.0000E+00		

3' ET Cover, Soil No. 1

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\3'\3'-S1.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\3'\3'-S10005.re
Date of Run: 23 May 2006
Time of Run: 13:43:52.33
Title:
Wasatch Landfill (3 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	Initial Conditions HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	3.301E+01	0.4563	294.43	2	3.000E-01	3.281E+01	0.4565	294.43
3	5.000E-01	3.261E+01	0.4566	294.43	4	8.000E-01	3.231E+01	0.4568	294.43
5	1.300E+00	3.182E+01	0.4571	294.43	6	2.100E+00	3.106E+01	0.4577	294.43
7	3.200E+00	3.019E+01	0.4583	294.43	8	4.900E+00	2.902E+01	0.4591	294.43
9	7.500E+00	2.761E+01	0.4602	294.43	10	1.130E+01	2.631E+01	0.4611	294.43
11	1.710E+01	2.621E+01	0.4612	294.43	12	2.430E+01	3.090E+01	0.4578	294.43
13	3.150E+01	5.060E+01	0.4457	294.43	14	3.870E+01	2.584E+02	0.3935	294.43
15	4.590E+01	6.246E+02	0.3631	294.43	16	5.310E+01	4.871E+02	0.3716	294.43
17	6.030E+01	3.701E+02	0.3810	294.43	18	6.750E+01	2.927E+02	0.3892	294.43
19	7.470E+01	2.402E+02	0.3960	294.43	20	8.050E+01	2.114E+02	0.4004	294.43
21	8.430E+01	1.976E+02	0.4027	294.43	22	8.690E+01	1.902E+02	0.4040	294.43
23	8.860E+01	1.862E+02	0.4048	294.43	24	8.970E+01	1.839E+02	0.4052	294.43
25	9.050E+01	1.824E+02	0.4055	294.43	26	9.100E+01	1.815E+02	0.4056	294.43
27	9.130E+01	1.810E+02	0.4057	294.43	28	9.150E+01	1.807E+02	0.4058	294.43
29	9.170E+01	1.803E+02	0.4059	294.43	30	9.180E+01	1.802E+02	0.4059	294.43
31	9.190E+01	1.775E+02	0.1139	294.43	32	9.210E+01	1.134E+02	0.1168	294.43
33	9.260E+01	8.484E+01	0.1196	294.43	34	9.340E+01	7.158E+01	0.1219	294.43
35	9.470E+01	6.347E+01	0.1237	294.43	36	9.680E+01	6.017E+01	0.1246	294.43
37	1.000E+02	9.119E+01	0.1188	294.43	38	1.050E+02	1.099E+02	0.1170	294.43
39	1.100E+02	1.030E+02	0.1176	294.43	40	1.150E+02	1.012E+02	0.1178	294.43

Initial Water Storage = 40.7266 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

```
Node Number          =        1           30
Depth (cm)           =      0.10000     91.80000
Water (cm3/cm3)      =      0.47969      0.40584
Head (cm)            = 5.95906E+00 1.80407E+02
LiqWater Flow (cm)= 1.24662E-01-1.25793E-04
IsoVapor Flow (cm)= 1.61920E-09-9.02648E-07
Plant Sink (cm)      = 0.00000E+00 0.00000E+00
```

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
40.7266+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0000 =	40.8536 vs.	40.8536

Mass Balance = 2.7909E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm

Transpiration: Potential = 0.0000 cm, Actual = 0.0000 cm

```
DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
-------------
Node Number        =        1          30
Depth (cm)         =      0.10000    91.80000
Water (cm3/cm3)    =      0.45626     0.41766
Head (cm)          = 3.30884E+01 1.27051E+02
LiqWater Flow (cm)= 4.20041E-05-3.67477E-04
IsoVapor Flow (cm)=-5.40170E-09-7.13479E-07
Plant Sink (cm)    = 0.00000E+00 0.00000E+00

                                                LIQUID
 PRESTOR    INFIL  RUNOFF    EVAPO   TRANS     DRAIN     NEWSTOR       STORAGE
 41.5506+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0010 =   41.5497 vs.   41.5497

Mass Balance = -1.7839E-08 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1
```

UNSAT-H Version 3.01
SIMULATION SUMMARY

Title:
Wasatch Landfill (3 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

Transpiration Scheme is:	=	1	
Potential Evapotranspiration	=	1.9154E+02	[cm]
Potential Transpiration	=	7.5007E+01	[cm]
Actual Transpiration	=	1.7945E+01	[cm]
Potential Evaporation	=	1.1663E+02	[cm]
Actual Evaporation	=	1.1469E+01	[cm]
Evaporation during Growth	=	7.2744E+00	[cm]
Total Runoff	=	1.0297E+01	[cm]
Total Infiltration	=	3.2248E+01	[cm]
Total Basal Liquid Flux (drainage)	=	1.5791E+00	[cm]
Total Basal Vapor Flux (temp-grad)	=	0.0000E+00	[cm]
Total Applied Water	=	4.2520E+01	[cm]
Actual Rainfall	=	4.2520E+01	[cm]
Actual Irrigation	=	0.0000E+00	[cm]
Total Final Moisture Storage	=	4.1550E+01	[cm]
Mass Balance Error	=	4.3200E-01	[cm]
Total Successful Time Steps	=	71028	
Total Attempted Time Steps	=	81240	
Total Time Step Reductions (DHMAX)	=	0	
Total Changes in Surface Boundary	=	30989	
Total Time Actually Simulated	=	3.6500E+02	[days]

Total liquid water flow (cm) across different depths at the end of 3.6500E+02 days:

DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW

0.100	2.0779E+01	0.200	2.7700E+01	0.400	2.5636E+01
0.650	2.4193E+01	1.050	2.2566E+01	1.700	2.0836E+01
2.650	1.8937E+01	4.050	1.6688E+01	6.200	1.4118E+01
9.400	1.1816E+01	14.200	1.0240E+01	20.700	8.8549E+00
27.900	7.4540E+00	35.100	6.4019E+00	42.300	5.5990E+00
49.500	4.8958E+00	56.700	4.2684E+00	63.900	3.7211E+00
71.100	3.2028E+00	77.600	2.7727E+00	82.400	2.4828E+00
85.600	2.3006E+00	87.750	2.1945E+00	89.150	2.1227E+00
90.100	2.0756E+00	90.750	2.0441E+00	91.150	2.0394E+00
91.400	2.0365E+00	91.600	2.0342E+00	91.750	2.0324E+00
91.850	2.0314E+00	92.000	2.0346E+00	92.350	2.0306E+00
93.000	2.0274E+00	94.050	2.0219E+00	95.750	2.0105E+00
98.400	1.9856E+00	102.500	1.9076E+00	107.500	1.7832E+00
112.500	1.6485E+00	115.000	1.5791E+00		

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	5.9018E-02	0.500	1.2148E-01
0.800	2.6028E-01	1.300	5.5228E-01	2.100	1.0646E+00
3.200	1.6468E+00	4.900	2.3550E+00	7.500	2.3475E+00
11.300	1.6752E+00	17.100	1.4077E+00	24.300	1.4013E+00
31.500	1.0565E+00	38.700	8.1089E-01	45.900	6.7064E-01
53.100	5.8358E-01	60.300	5.0600E-01	67.500	4.6192E-01
74.700	3.6767E-01	80.500	2.4086E-01	84.300	1.4820E-01
86.900	9.1355E-02	88.600	5.6112E-02	89.700	3.6270E-02
90.500	2.3976E-02	91.000	0.0000E+00	91.300	0.0000E+00
91.500	0.0000E+00	91.700	0.0000E+00	91.800	0.0000E+00
91.900	0.0000E+00	92.100	0.0000E+00	92.600	0.0000E+00
93.400	0.0000E+00	94.700	0.0000E+00	96.800	0.0000E+00
100.000	0.0000E+00	105.000	0.0000E+00	110.000	0.0000E+00
115.000	0.0000E+00				

3' ET Cover, Soil No. 2

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\3'\3'-S2.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\3'\3'-S20005.re
Date of Run: 23 May 2006
Time of Run: 14:04:51.96
Title:
Wasatch Landfill (3 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)

		Initial Conditions					Initial Conditions		
NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	1.260E+02	0.4035	294.43	2	3.000E-01	1.258E+02	0.4036	294.43
3	5.000E-01	1.256E+02	0.4036	294.43	4	8.000E-01	1.253E+02	0.4037	294.43
5	1.300E+00	1.248E+02	0.4039	294.43	6	2.100E+00	1.241E+02	0.4041	294.43
7	3.200E+00	1.238E+02	0.4041	294.43	8	4.900E+00	1.242E+02	0.4040	294.43
9	7.500E+00	1.265E+02	0.4034	294.43	10	1.130E+01	1.345E+02	0.4011	294.43
11	1.710E+01	1.616E+02	0.3940	294.43	12	2.430E+01	2.534E+02	0.3750	294.43
13	3.150E+01	6.818E+02	0.3297	294.43	14	3.870E+01	1.837E+03	0.2855	294.43
15	4.590E+01	2.046E+03	0.2810	294.43	16	5.310E+01	1.956E+03	0.2829	294.43
17	6.030E+01	1.988E+03	0.2822	294.43	18	6.750E+01	2.194E+03	0.2781	294.43
19	7.470E+01	2.640E+03	0.2704	294.43	20	8.050E+01	3.214E+03	0.2625	294.43
21	8.430E+01	3.636E+03	0.2577	294.43	22	8.690E+01	3.882E+03	0.2551	294.43
23	8.860E+01	3.995E+03	0.2540	294.43	24	8.970E+01	4.041E+03	0.2536	294.43
25	9.050E+01	4.059E+03	0.2534	294.43	26	9.100E+01	4.063E+03	0.2534	294.43
27	9.130E+01	4.063E+03	0.2534	294.43	28	9.150E+01	4.062E+03	0.2534	294.43
29	9.170E+01	4.060E+03	0.2534	294.43	30	9.180E+01	4.059E+03	0.2534	294.43
31	9.190E+01	3.994E+03	0.1101	294.43	32	9.210E+01	3.905E+03	0.1101	294.43
33	9.260E+01	3.680E+03	0.1101	294.43	34	9.340E+01	3.319E+03	0.1101	294.43
35	9.470E+01	2.731E+03	0.1101	294.43	36	9.680E+01	1.770E+03	0.1102	294.43
37	1.000E+02	2.734E+02	0.1123	294.43	38	1.050E+02	1.095E+02	0.1171	294.43
39	1.100E+02	1.021E+02	0.1177	294.43	40	1.150E+02	1.008E+02	0.1178	294.43

Initial Water Storage = 31.5461 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

```
Node Number          =       1           30
Depth (cm)           =     0.10000    91.80000
Water (cm3/cm3)      =     0.42836     0.25348
Head (cm)            = 5.57025E+01 4.05340E+03
LiqWater Flow (cm)= 1.24516E-01-1.24953E-07
IsoVapor Flow (cm)= 3.45301E-09-3.43250E-05
Plant Sink (cm)      = 0.00000E+00 0.00000E+00
```

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR		STORAGE
31.5461+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0000 =	31.6731	vs.	31.6731

Mass Balance = 2.6616E-06 cm; Time step attempts = 183 and successes = 183
Evaporation: Potential = 0.0000 cm, Actual = 0.0000 cm

```
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm

--------------------------------------------------------------------------------

DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
-------------
Node Number         =       1          30
Depth (cm)          =     0.10000    91.80000
Water (cm3/cm3)     =     0.40352     0.25313
Head (cm)           = 1.25999E+02 4.09049E+03
LiqWater Flow (cm)= 8.09462E-05-8.88639E-08
IsoVapor Flow (cm)=-9.31863E-09-2.55286E-05
Plant Sink (cm)     = 0.00000E+00 0.00000E+00

                                               LIQUID
 PRESTOR    INFIL  RUNOFF    EVAPO   TRANS    DRAIN      NEWSTOR        STORAGE
 31.5231+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0000 =   31.5231 vs.   31.5231

Mass Balance = -9.9596E-10 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1

--------------------------------------------------------------------------------
                              UNSAT-H Version 3.01
                               SIMULATION SUMMARY

Title:
Wasatch Landfill (3 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
--------------------------------------------------------------------------------

Transpiration Scheme is:                =     1
Potential Evapotranspiration            =  1.9154E+02     [cm]
Potential Transpiration                 =  7.5007E+01     [cm]
Actual Transpiration                    =  1.6535E+01     [cm]
Potential Evaporation                   =  1.1663E+02     [cm]
Actual Evaporation                      =  1.5484E+01     [cm]
Evaporation during Growth               =  9.9432E+00     [cm]
Total Runoff                            =  1.0759E+01     [cm]
Total Infiltration                      =  3.1761E+01     [cm]
Total Basal Liquid Flux (drainage)      =  6.3850E-04     [cm]
Total Basal Vapor Flux (temp-grad)      =  0.0000E+00     [cm]
Total Applied Water                     =  4.2520E+01     [cm]
Actual Rainfall                         =  4.2520E+01     [cm]
Actual Irrigation                       =  0.0000E+00     [cm]
Total Final Moisture Storage            =  3.1523E+01     [cm]
Mass Balance Error                      = -2.3598E-01     [cm]
Total Successful Time Steps             =     60075
Total Attempted Time Steps              =     60565
Total Time Step Reductions (DHMAX)      =         0
Total Changes in Surface Boundary       =     27084
Total Time Actually Simulated           =  3.6500E+02     [days]


Total liquid water flow (cm) across different depths at the end of 3.6500E+02
days:

   DEPTH         FLOW        DEPTH        FLOW        DEPTH         FLOW
  --------    -----------   --------   -----------   --------   -----------
```

0.100	1.6277E+01	0.200	2.3753E+01	0.400	2.1600E+01
0.650	2.0062E+01	1.050	1.8535E+01	1.700	1.7270E+01
2.650	1.5838E+01	4.050	1.3991E+01	6.200	1.1652E+01
9.400	9.2997E+00	14.200	7.5005E+00	20.700	5.8892E+00
27.900	4.6212E+00	35.100	3.7085E+00	42.300	2.9745E+00
49.500	2.3463E+00	56.700	1.7809E+00	63.900	1.2554E+00
71.100	7.8298E-01	77.600	4.3586E-01	82.400	2.4150E-01
85.600	1.3602E-01	87.750	7.2624E-02	89.150	3.3047E-02
90.100	6.4504E-03	90.750	-1.1794E-02	91.150	-1.1690E-02
91.400	-1.1621E-02	91.600	-1.1565E-02	91.750	-1.1522E-02
91.850	-4.7924E-05	92.000	-2.9871E-09	92.350	-3.6447E-09
93.000	-5.3968E-09	94.050	-1.1033E-08	95.750	-4.8221E-08
98.400	-5.8205E-06	102.500	-7.2714E-04	107.500	-4.1604E-04
112.500	4.0422E-04	115.000	6.3850E-04		

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	5.1276E-02	0.500	7.6826E-02
0.800	1.4581E-01	1.300	2.7539E-01	2.100	6.3258E-01
3.200	1.4021E+00	4.900	2.2018E+00	7.500	2.3429E+00
11.300	1.8488E+00	17.100	1.6154E+00	24.300	1.2850E+00
31.500	9.2936E-01	38.700	7.3308E-01	45.900	6.2894E-01
53.100	5.6631E-01	60.300	5.2650E-01	67.500	4.7327E-01
74.700	3.4782E-01	80.500	1.9500E-01	84.300	1.0642E-01
86.900	6.4431E-02	88.600	4.0415E-02	89.700	2.7213E-02
90.500	1.8677E-02	91.000	0.0000E+00	91.300	0.0000E+00
91.500	0.0000E+00	91.700	0.0000E+00	91.800	0.0000E+00
91.900	0.0000E+00	92.100	0.0000E+00	92.600	0.0000E+00
93.400	0.0000E+00	94.700	0.0000E+00	96.800	0.0000E+00
100.000	0.0000E+00	105.000	0.0000E+00	110.000	0.0000E+00
115.000	0.0000E+00				

4' ET Cover, Soil No. 1

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\4'\4'-S1.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 1\4'\4'-S10005.re
Date of Run: 23 May 2006
Time of Run: 13:41:16.58
Title:
Wasatch Landfill (4 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)

		Initial Conditions					Initial Conditions		
NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	3.308E+01	0.4563	294.43	2	3.000E-01	3.288E+01	0.4564	294.43
3	5.000E-01	3.268E+01	0.4565	294.43	4	8.000E-01	3.238E+01	0.4567	294.43
5	1.300E+00	3.189E+01	0.4571	294.43	6	2.100E+00	3.113E+01	0.4576	294.43
7	3.200E+00	3.026E+01	0.4582	294.43	8	4.900E+00	2.909E+01	0.4591	294.43
9	7.500E+00	2.769E+01	0.4601	294.43	10	1.130E+01	2.643E+01	0.4611	294.43
11	1.710E+01	2.640E+01	0.4611	294.43	12	2.440E+01	3.143E+01	0.4574	294.43
13	3.170E+01	5.267E+01	0.4446	294.43	14	3.900E+01	3.128E+02	0.3869	294.43
15	4.630E+01	7.319E+02	0.3578	294.43	16	5.360E+01	6.289E+02	0.3629	294.43
17	6.090E+01	5.648E+02	0.3666	294.43	18	6.820E+01	5.574E+02	0.3670	294.43
19	7.550E+01	6.015E+02	0.3644	294.43	20	8.280E+01	7.074E+02	0.3590	294.43
21	9.010E+01	8.733E+02	0.3519	294.43	22	9.740E+01	1.026E+03	0.3466	294.43
23	1.047E+02	1.632E+03	0.3316	294.43	24	1.105E+02	2.097E+03	0.3238	294.43
25	1.143E+02	2.192E+03	0.3224	294.43	26	1.169E+02	2.189E+03	0.3225	294.43
27	1.186E+02	2.172E+03	0.3227	294.43	28	1.197E+02	2.159E+03	0.3229	294.43
29	1.205E+02	2.148E+03	0.3230	294.43	30	1.210E+02	2.141E+03	0.3231	294.43
31	1.213E+02	2.137E+03	0.3232	294.43	32	1.215E+02	2.135E+03	0.3232	294.43
33	1.217E+02	2.132E+03	0.3233	294.43	34	1.218E+02	2.131E+03	0.3233	294.43
35	1.219E+02	2.129E+03	0.3233	294.43	36	1.220E+02	2.090E+03	0.1102	294.43
37	1.222E+02	2.040E+03	0.1102	294.43	38	1.227E+02	1.915E+03	0.1102	294.43
39	1.235E+02	1.715E+03	0.1102	294.43	40	1.248E+02	1.391E+03	0.1103	294.43
41	1.269E+02	8.699E+02	0.1106	294.43	42	1.301E+02	1.356E+02	0.1154	294.43
43	1.351E+02	1.064E+02	0.1173	294.43	44	1.401E+02	1.016E+02	0.1177	294.43
45	1.451E+02	1.007E+02	0.1178	294.43					

Initial Water Storage = 49.3793 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

```
Node Number          =          1          35
Depth (cm)           =    0.10000   121.90000
Water (cm3/cm3)      =    0.47967     0.32332
Head (cm)            = 5.97866E+00 2.12920E+03
LiqWater Flow (cm)= 1.24660E-01-3.03519E-07
IsoVapor Flow (cm)= 1.63398E-09-1.89158E-05
Plant Sink (cm)      = 0.00000E+00 0.00000E+00
```

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR		STORAGE
49.3793+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0000 =	49.5063	vs.	49.5063

```
 Mass Balance =  2.7928E-06 cm;  Time step attempts =  183 and successes =  183
   Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
 Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm

-------------------------------------------------------------------------------


 DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
 -------------
 Node Number        =       1          35
 Depth (cm)         =     0.10000   121.90000
 Water (cm3/cm3)    =     0.45631     0.32848
 Head (cm)          = 3.30219E+01 1.80436E+03
 LiqWater Flow (cm)= 4.18878E-05-3.78926E-07
 IsoVapor Flow (cm)=-5.39352E-09-1.30383E-05
 Plant Sink (cm)    = 0.00000E+00 0.00000E+00

                                               LIQUID
  PRESTOR   INFIL  RUNOFF    EVAPO   TRANS     DRAIN     NEWSTOR       STORAGE
  50.4046+ 0.0000+ 0.0000 - 0.0000- 0.0000-  0.0000 =   50.4046 vs.   50.4046

 Mass Balance = -1.7392E-10 cm;  Time step attempts =  160 and successes =  160
   Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
 Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1

-------------------------------------------------------------------------------
                             UNSAT-H Version 3.01
                              SIMULATION SUMMARY

 Title:
 Wasatch Landfill (4 ft THICK ET COVER, Soil #1, 5x Max. Precip. YEAR)
-------------------------------------------------------------------------------

 Transpiration Scheme is:             =    1
 Potential Evapotranspiration         =  1.9154E+02     [cm]
 Potential Transpiration              =  7.5007E+01     [cm]
 Actual Transpiration                 =  1.9069E+01     [cm]
 Potential Evaporation                =  1.1663E+02     [cm]
 Actual Evaporation                   =  1.1469E+01     [cm]
 Evaporation during Growth            =  7.2776E+00     [cm]
 Total Runoff                         =  1.0561E+01     [cm]
 Total Infiltration                   =  3.1978E+01     [cm]
 Total Basal Liquid Flux (drainage)   =  6.4613E-04     [cm]
 Total Basal Vapor Flux (temp-grad)   =  0.0000E+00     [cm]
 Total Applied Water                  =  4.2520E+01     [cm]
 Actual Rainfall                      =  4.2520E+01     [cm]
 Actual Irrigation                    =  0.0000E+00     [cm]
 Total Final Moisture Storage         =  5.0405E+01     [cm]
 Mass Balance Error                   =  4.1479E-01     [cm]
 Total Successful Time Steps          =     68077
 Total Attempted Time Steps           =     75348
 Total Time Step Reductions (DHMAX)   =         0
 Total Changes in Surface Boundary    =     30274
 Total Time Actually Simulated        =  3.6500E+02    [days]


 Total liquid water flow (cm) across different depths at the end of 3.6500E+02
days:
```

DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW
0.100	2.0510E+01	0.200	2.7439E+01	0.400	2.5381E+01
0.650	2.3934E+01	1.050	2.2331E+01	1.700	2.0596E+01
2.650	1.8698E+01	4.050	1.6442E+01	6.200	1.3893E+01
9.400	1.1585E+01	14.200	1.0001E+01	20.750	8.6054E+00
28.050	7.1866E+00	35.350	6.1317E+00	42.650	5.3009E+00
49.950	4.6040E+00	57.250	3.9906E+00	64.550	3.4237E+00
71.850	2.8559E+00	79.150	2.2241E+00	86.450	1.4407E+00
93.750	6.0901E-01	101.050	4.3142E-01	107.600	2.2414E-01
112.400	9.8345E-02	115.600	4.3790E-02	117.750	2.0499E-02
119.150	9.6597E-03	120.100	3.6431E-03	120.750	-1.7864E-05
121.150	-2.1520E-03	121.400	-3.4545E-03	121.600	-4.4841E-03
121.750	-5.2497E-03	121.850	-5.7586E-03	121.950	-1.1566E-04
122.100	-4.2913E-08	122.450	-5.2950E-08	123.100	-8.0329E-08
124.150	-1.7311E-07	125.850	-8.7908E-07	128.500	-2.3133E-04
132.600	-1.4486E-03	137.600	-1.0600E-04	142.600	4.7461E-04
145.100	6.4613E-04				

Total plant water uptake (cm) at different depths:

DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	5.8769E-02	0.500	1.2075E-01
0.800	2.5952E-01	1.300	5.5065E-01	2.100	1.0633E+00
3.200	1.6478E+00	4.900	2.3493E+00	7.500	2.3547E+00
11.300	1.6926E+00	17.100	1.4179E+00	24.400	1.4117E+00
31.700	1.0540E+00	39.000	8.0529E-01	46.300	6.6702E-01
53.600	5.9045E-01	60.900	5.4115E-01	68.200	5.2835E-01
75.500	5.7559E-01	82.800	6.9195E-01	90.100	6.8821E-01
97.400	0.0000E+00	104.700	0.0000E+00	110.500	0.0000E+00
114.300	0.0000E+00	116.900	0.0000E+00	118.600	0.0000E+00
119.700	0.0000E+00	120.500	0.0000E+00	121.000	0.0000E+00
121.300	0.0000E+00	121.500	0.0000E+00	121.700	0.0000E+00
121.800	0.0000E+00	121.900	0.0000E+00	122.000	0.0000E+00
122.200	0.0000E+00	122.700	0.0000E+00	123.500	0.0000E+00
124.800	0.0000E+00	126.900	0.0000E+00	130.100	0.0000E+00
135.100	0.0000E+00	140.100	0.0000E+00	145.100	0.0000E+00

4’ ET Cover, Soil No. 2

UNSAT-H Version 3.01
INITIAL CONDITIONS

Input File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\4'\4'-S2.inp
Results File: N:\Wasatch\Alternative Final Cover\UNSAT-H\Soil 2\4'\4'-S20005.re
Date of Run: 23 May 2006
Time of Run: 14:13:36.18
Title:
Wasatch Landfill (4 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)

		Initial Conditions					Initial Conditions		
NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)	NODE	DEPTH (cm)	HEAD (cm)	THETA (vol.)	TEMP (K)
1	1.000E-01	1.257E+02	0.4036	294.43	2	3.000E-01	1.255E+02	0.4037	294.43
3	5.000E-01	1.253E+02	0.4037	294.43	4	8.000E-01	1.250E+02	0.4038	294.43
5	1.300E+00	1.245E+02	0.4039	294.43	6	2.100E+00	1.238E+02	0.4042	294.43
7	3.200E+00	1.236E+02	0.4042	294.43	8	4.900E+00	1.239E+02	0.4041	294.43
9	7.500E+00	1.263E+02	0.4034	294.43	10	1.130E+01	1.341E+02	0.4012	294.43
11	1.710E+01	1.610E+02	0.3941	294.43	12	2.440E+01	2.539E+02	0.3749	294.43
13	3.170E+01	6.990E+02	0.3285	294.43	14	3.900E+01	1.834E+03	0.2856	294.43
15	4.630E+01	2.009E+03	0.2818	294.43	16	5.360E+01	1.917E+03	0.2837	294.43
17	6.090E+01	1.945E+03	0.2831	294.43	18	6.820E+01	2.129E+03	0.2793	294.43
19	7.550E+01	2.497E+03	0.2727	294.43	20	8.280E+01	2.981E+03	0.2655	294.43
21	9.010E+01	3.101E+03	0.2640	294.43	22	9.740E+01	2.653E+03	0.2702	294.43
23	1.047E+02	2.299E+03	0.2761	294.43	24	1.105E+02	2.134E+03	0.2792	294.43
25	1.143E+02	2.066E+03	0.2806	294.43	26	1.169E+02	2.034E+03	0.2812	294.43
27	1.186E+02	2.018E+03	0.2815	294.43	28	1.197E+02	2.010E+03	0.2817	294.43
29	1.205E+02	2.006E+03	0.2818	294.43	30	1.210E+02	2.003E+03	0.2819	294.43
31	1.213E+02	2.002E+03	0.2819	294.43	32	1.215E+02	2.001E+03	0.2819	294.43
33	1.217E+02	2.000E+03	0.2819	294.43	34	1.218E+02	2.000E+03	0.2819	294.43
35	1.219E+02	2.000E+03	0.2819	294.43	36	1.220E+02	1.950E+03	0.1102	294.43
37	1.222E+02	1.882E+03	0.1102	294.43	38	1.227E+02	1.714E+03	0.1102	294.43
39	1.235E+02	1.446E+03	0.1103	294.43	40	1.248E+02	1.013E+03	0.1105	294.43
41	1.269E+02	3.364E+02	0.1118	294.43	42	1.301E+02	1.201E+02	0.1163	294.43
43	1.351E+02	1.047E+02	0.1175	294.43	44	1.401E+02	1.012E+02	0.1178	294.43
45	1.451E+02	1.005E+02	0.1178	294.43					

Initial Water Storage = 40.0547 cm

NOTE: There are no temperature data when plants are modelled.

DAILY SUMMARY: Day = 1, Simulated Time = 24.0000 hr

Node Number	=	1	35
Depth (cm)	=	0.10000	121.90000
Water (cm3/cm3)	=	0.42842	0.28192
Head (cm)	=	5.55745E+01	2.00046E+03
LiqWater Flow (cm)	=	1.24518E-01	-1.25601E-06
IsoVapor Flow (cm)	=	3.41589E-09	-2.47014E-05
Plant Sink (cm)	=	0.00000E+00	0.00000E+00

PRESTOR	INFIL	RUNOFF	EVAPO	TRANS	LIQUID DRAIN	NEWSTOR	STORAGE
40.0547+	0.1270+	0.0000 -	0.0000-	0.0000-	0.0000 =	40.1817 vs.	40.1817

```
Mass Balance =  2.6610E-06 cm;  Time step attempts =  183 and successes =  183
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm

--------------------------------------------------------------------------------


DAILY SUMMARY:  Day = 365, Simulated Time = 24.0000 hr
--------------
Node Number          =        1          35
Depth (cm)           =     0.10000   121.90000
Water (cm3/cm3)      =     0.40360     0.27738
Head (cm)            = 1.25728E+02 2.22988E+03
LiqWater Flow (cm)= 8.08242E-05-6.71923E-07
IsoVapor Flow (cm)=-9.30432E-09-2.01277E-05
Plant Sink (cm)      = 0.00000E+00 0.00000E+00

                                                  LIQUID
 PRESTOR    INFIL  RUNOFF    EVAPO   TRANS     DRAIN     NEWSTOR        STORAGE
 39.8894+ 0.0000+ 0.0000 - 0.0000- 0.0000-   0.0000 =   39.8894 vs.   39.8894

Mass Balance = -1.0112E-09 cm;  Time step attempts =  160 and successes =  160
  Evaporation:  Potential =  0.0000 cm, Actual =  0.0000 cm
Transpiration:  Potential =  0.0000 cm, Actual =  0.0000 cm
1
--------------------------------------------------------------------------------
                          UNSAT-H Version 3.01
                           SIMULATION SUMMARY

Title:
Wasatch Landfill (4 ft THICK ET COVER, Soil #2, 5x Max. Precip. YEAR)
--------------------------------------------------------------------------------

Transpiration Scheme is:              =    1
Potential Evapotranspiration          =  1.9154E+02     [cm]
Potential Transpiration               =  7.5007E+01     [cm]
Actual Transpiration                  =  1.6697E+01     [cm]
Potential Evaporation                 =  1.1663E+02     [cm]
Actual Evaporation                    =  1.5494E+01     [cm]
Evaporation during Growth             =  9.9508E+00     [cm]
Total Runoff                          =  1.0826E+01     [cm]
Total Infiltration                    =  3.1693E+01     [cm]
Total Basal Liquid Flux (drainage)    =  6.5492E-04     [cm]
Total Basal Vapor Flux (temp-grad)    =  0.0000E+00     [cm]
Total Applied Water                   =  4.2520E+01     [cm]
Actual Rainfall                       =  4.2520E+01     [cm]
Actual Irrigation                     =  0.0000E+00     [cm]
Total Final Moisture Storage          =  3.9889E+01     [cm]
Mass Balance Error                    = -3.3313E-01     [cm]
Total Successful Time Steps           =      60017
Total Attempted Time Steps            =      60480
Total Time Step Reductions (DHMAX)    =          0
Total Changes in Surface Boundary     =      27111
Total Time Actually Simulated         =  3.6500E+02     [days]


Total liquid water flow (cm) across different depths at the end of 3.6500E+02
days:
```

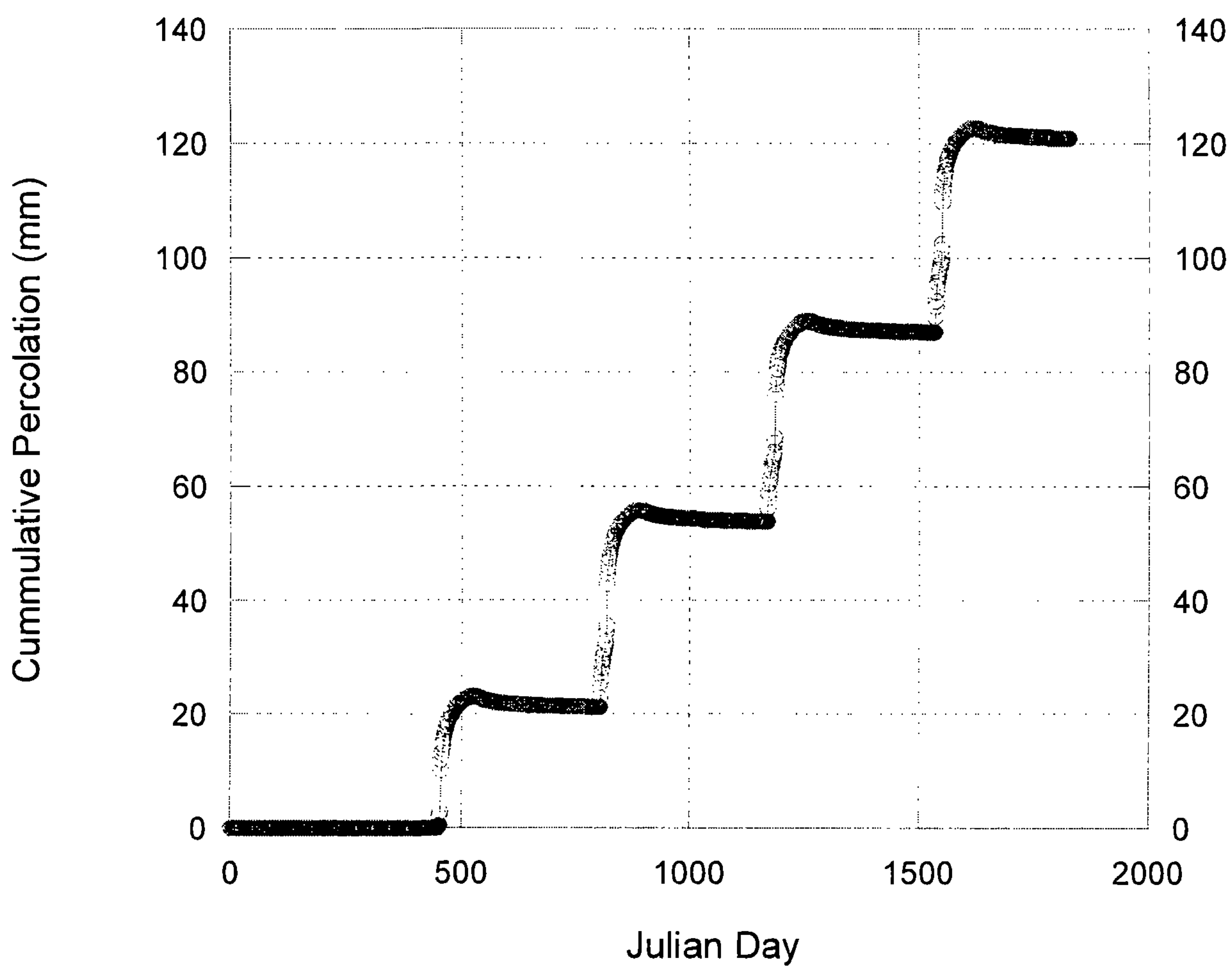
DEPTH	FLOW	DEPTH	FLOW	DEPTH	FLOW
0.100	1.6199E+01	0.200	2.3703E+01	0.400	2.1547E+01
0.650	2.0008E+01	1.050	1.8478E+01	1.700	1.7213E+01
2.650	1.5784E+01	4.050	1.3944E+01	6.200	1.1614E+01
9.400	9.2703E+00	14.200	7.4819E+00	20.750	5.8666E+00
28.050	4.5925E+00	35.350	3.6885E+00	42.650	2.9682E+00
49.950	2.3341E+00	57.250	1.7621E+00	64.550	1.2301E+00
71.850	7.5252E-01	79.150	3.6489E-01	86.450	9.1175E-02
93.750	-1.2370E-01	101.050	-9.8051E-02	107.600	-7.1787E-02
112.400	-5.1237E-02	115.600	-3.7137E-02	117.750	-2.7529E-02
119.150	-2.1229E-02	120.100	-1.6939E-02	120.750	-1.3997E-02
121.150	-1.2184E-02	121.400	-1.1051E-02	121.600	-1.0144E-02
121.750	-9.4629E-03	121.850	-9.0090E-03	121.950	-3.4123E-04
122.100	-5.1725E-08	122.450	-6.8648E-08	123.100	-1.2204E-07
124.150	-3.7663E-07	125.850	-7.4438E-06	128.500	-6.7731E-04
132.600	-1.0010E-03	137.600	7.9110E-05	142.600	5.2440E-04
145.100	6.5492E-04				

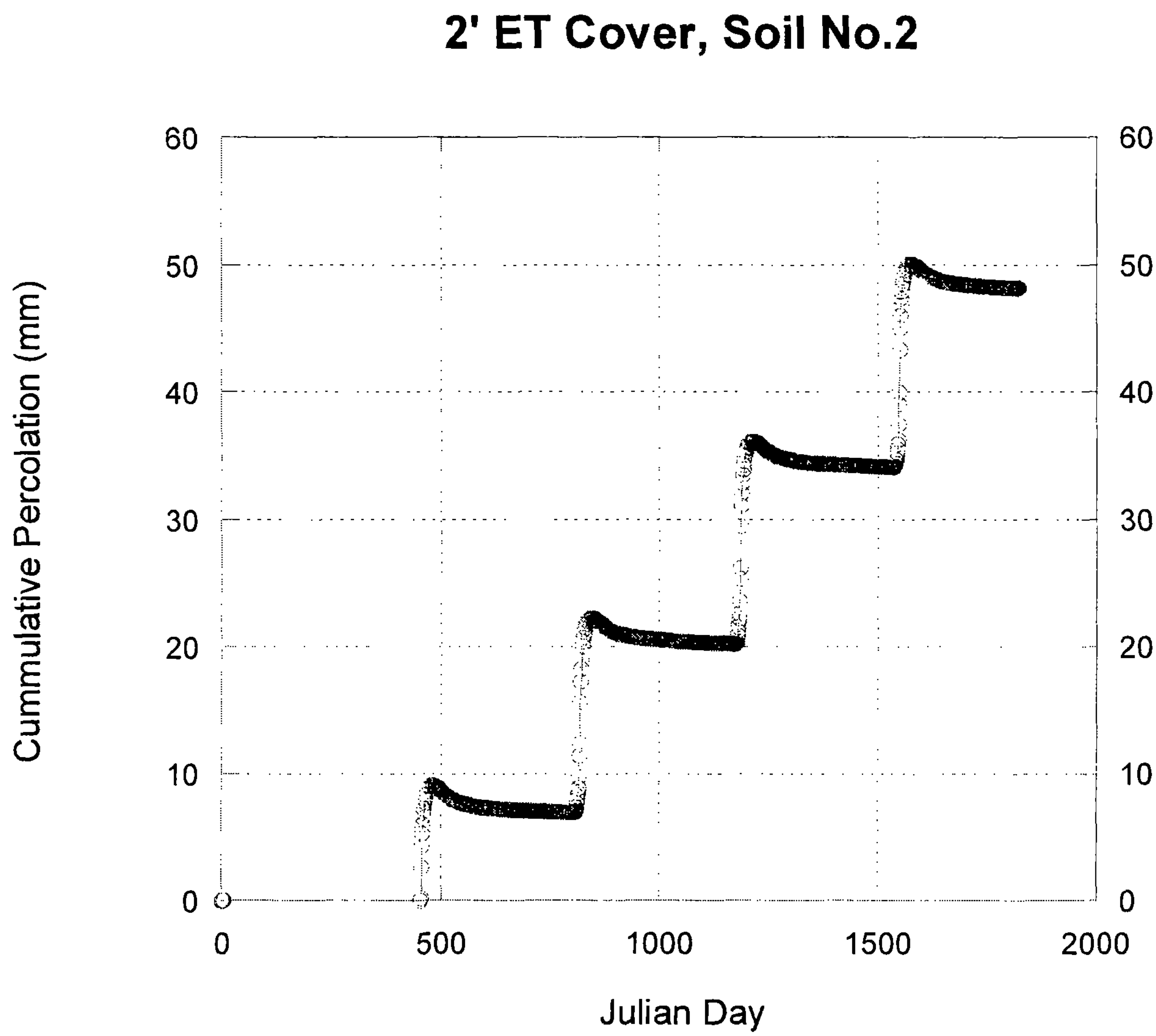
Total plant water uptake (cm) at different depths:

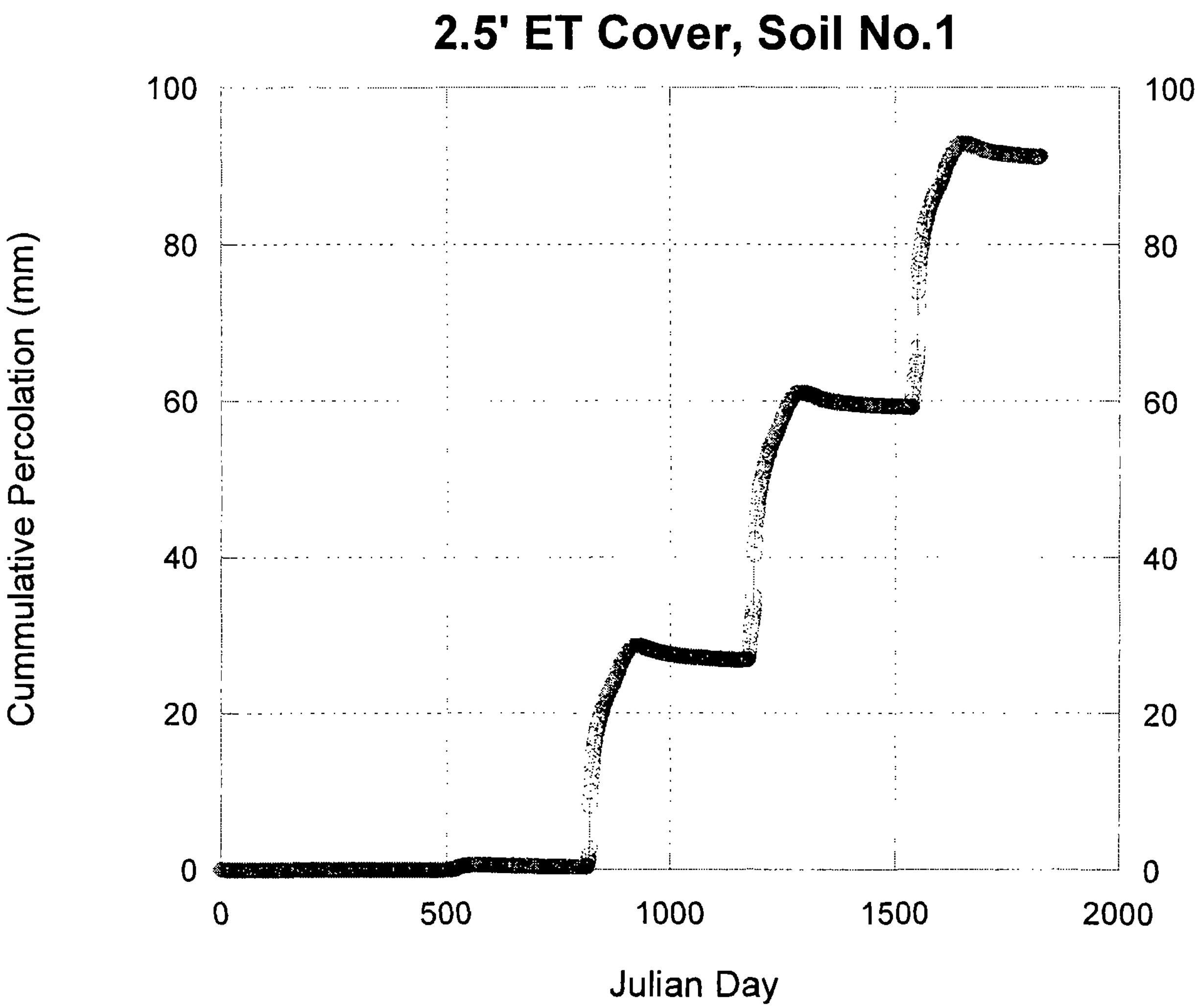
DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE	DEPTH	WATER UPTAKE
0.100	0.0000E+00	0.300	5.1100E-02	0.500	7.6571E-02
0.800	1.4533E-01	1.300	2.7452E-01	2.100	6.3104E-01
3.200	1.3991E+00	4.900	2.1980E+00	7.500	2.3409E+00
11.300	1.8499E+00	17.100	1.6286E+00	24.400	1.2974E+00
31.700	9.3441E-01	39.000	7.3709E-01	46.300	6.3400E-01
53.600	5.7217E-01	60.900	5.3265E-01	68.200	4.7918E-01
75.500	3.9198E-01	82.800	2.8553E-01	90.100	2.3756E-01
97.400	0.0000E+00	104.700	0.0000E+00	110.500	0.0000E+00
114.300	0.0000E+00	116.900	0.0000E+00	118.600	0.0000E+00
119.700	0.0000E+00	120.500	0.0000E+00	121.000	0.0000E+00
121.300	0.0000E+00	121.500	0.0000E+00	121.700	0.0000E+00
121.800	0.0000E+00	121.900	0.0000E+00	122.000	0.0000E+00
122.200	0.0000E+00	122.700	0.0000E+00	123.500	0.0000E+00
124.800	0.0000E+00	126.900	0.0000E+00	130.100	0.0000E+00
135.100	0.0000E+00	140.100	0.0000E+00	145.100	0.0000E+00

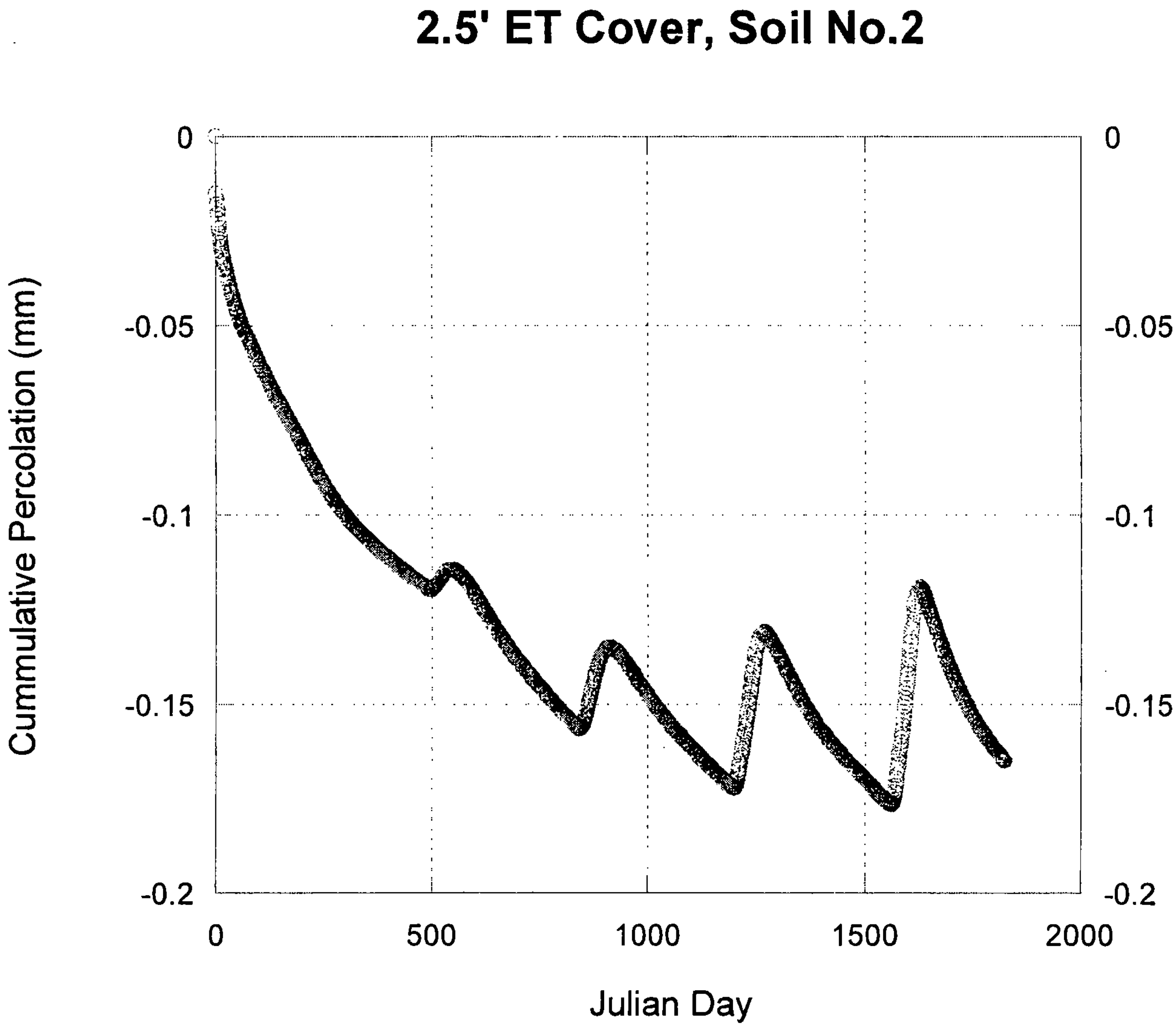
APPENDIX E
UNSAT-H CUMULATIVE PERCOLATION PLOTS

2' ET Cover, Soil No.1

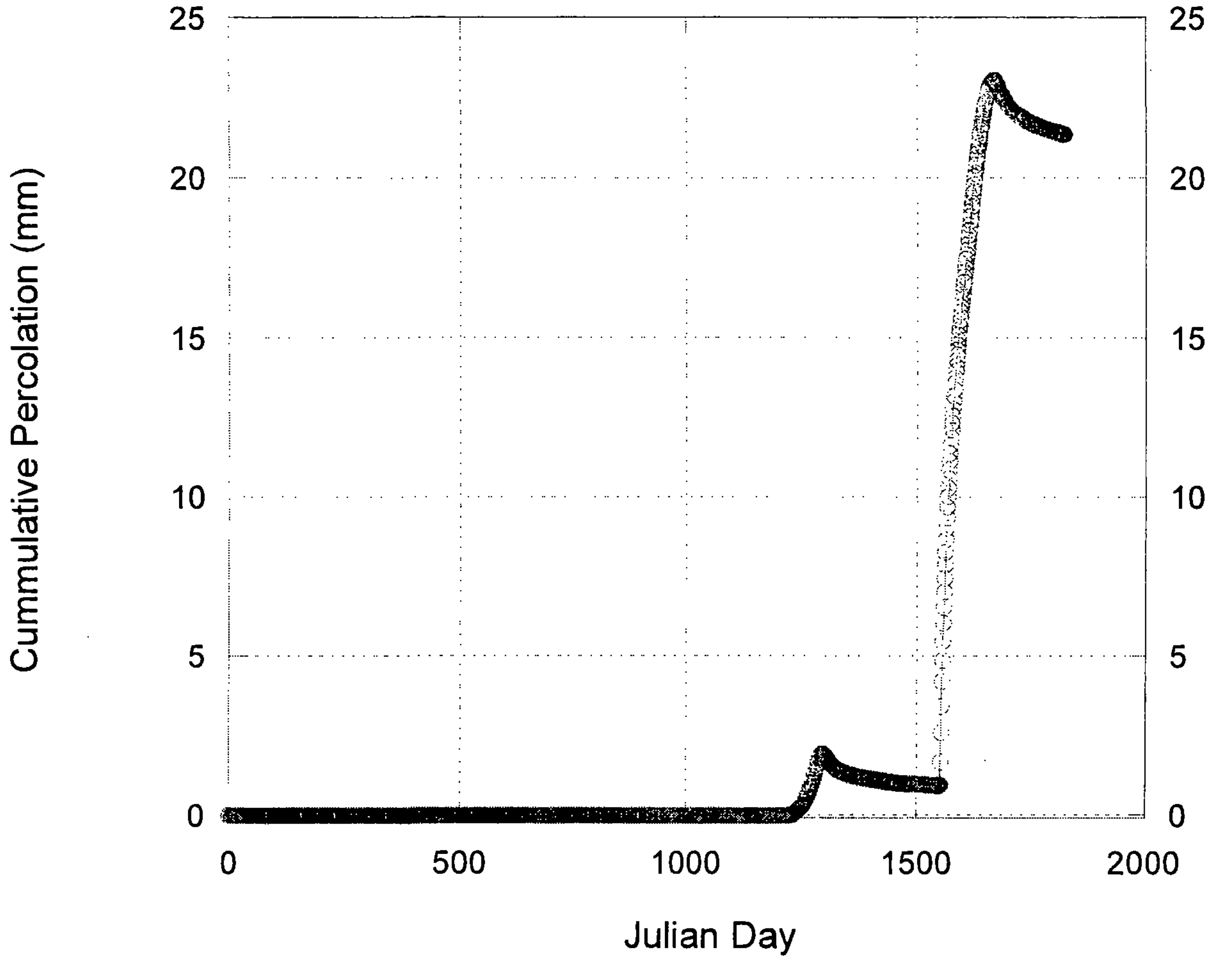



2' ET Cover, Soil No.2
Cummulative Percolation (mm)
Julian Day
0
10
20
30
40
50
60
0
500
1000
1500
2000

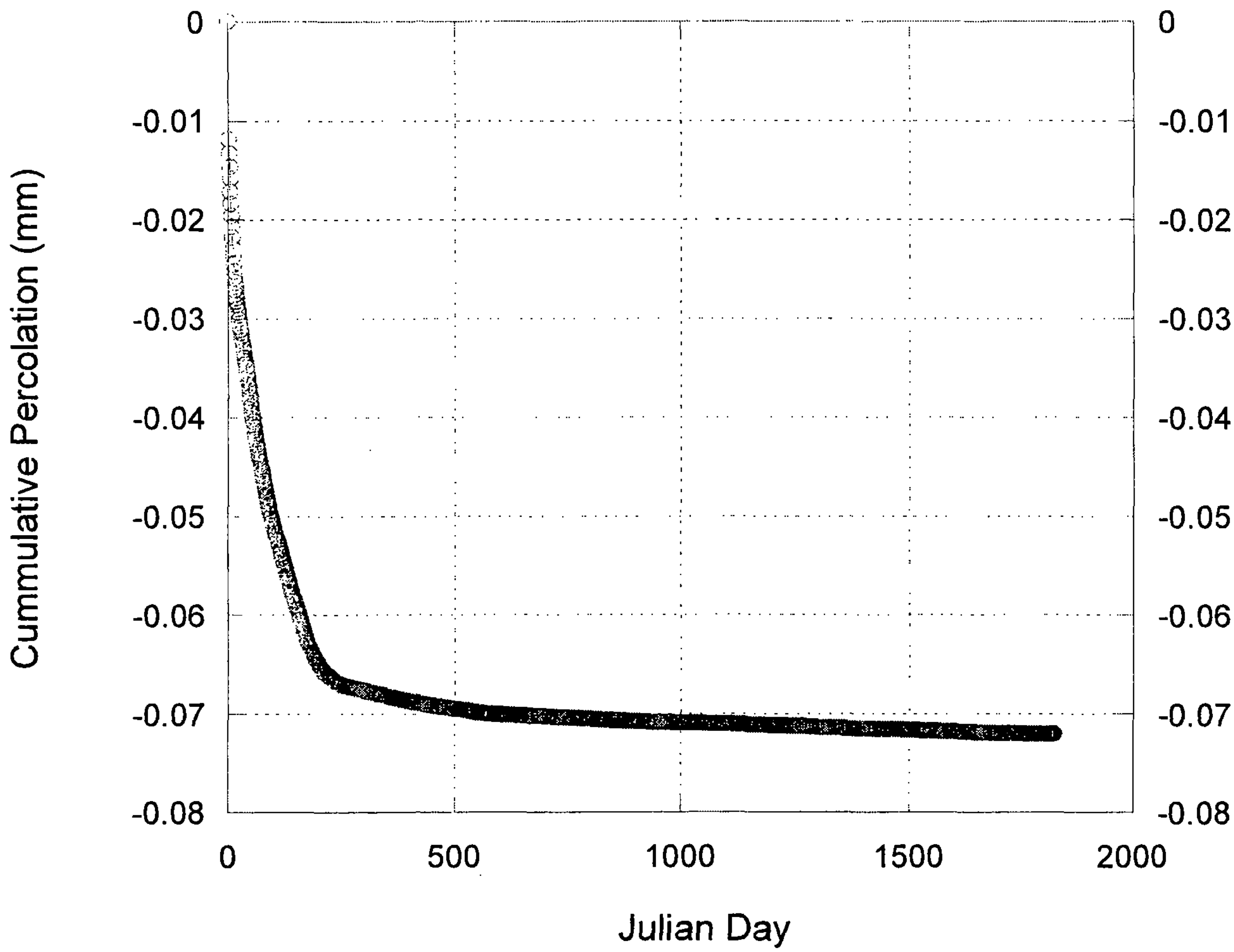

2.5' ET Cover, Soil No.1
Cummulative Percolation (mm)
Julian Day
100
80
60
40
20
0
0
500
1000
1500
2000


2.5' ET Cover, Soil No.2
Cummulative Percolation (mm)
0
-0.05
-0.1
-0.15
-0.2
0
500
1000
1500
2000
Julian Day

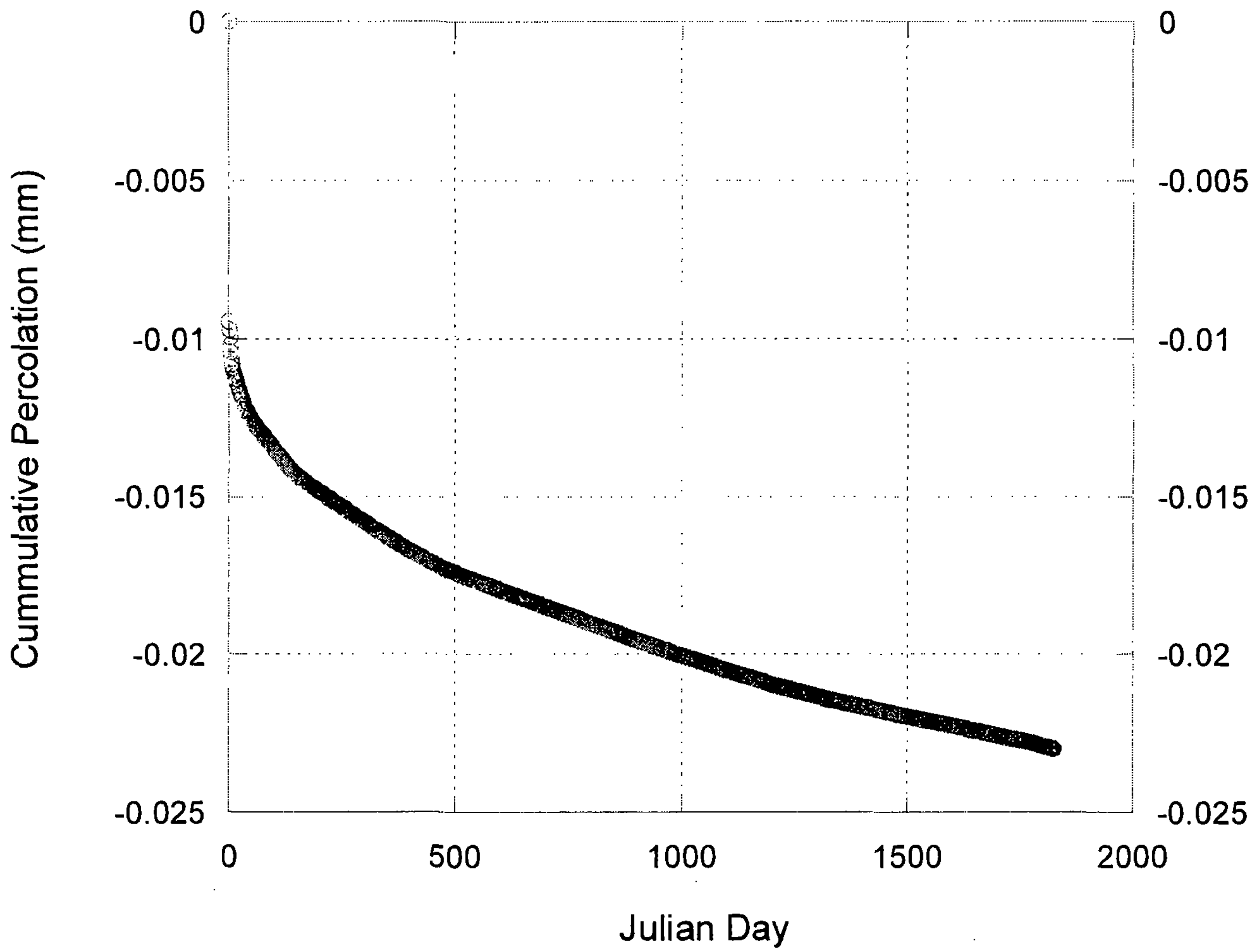
3' ET Cover, Soil No.1

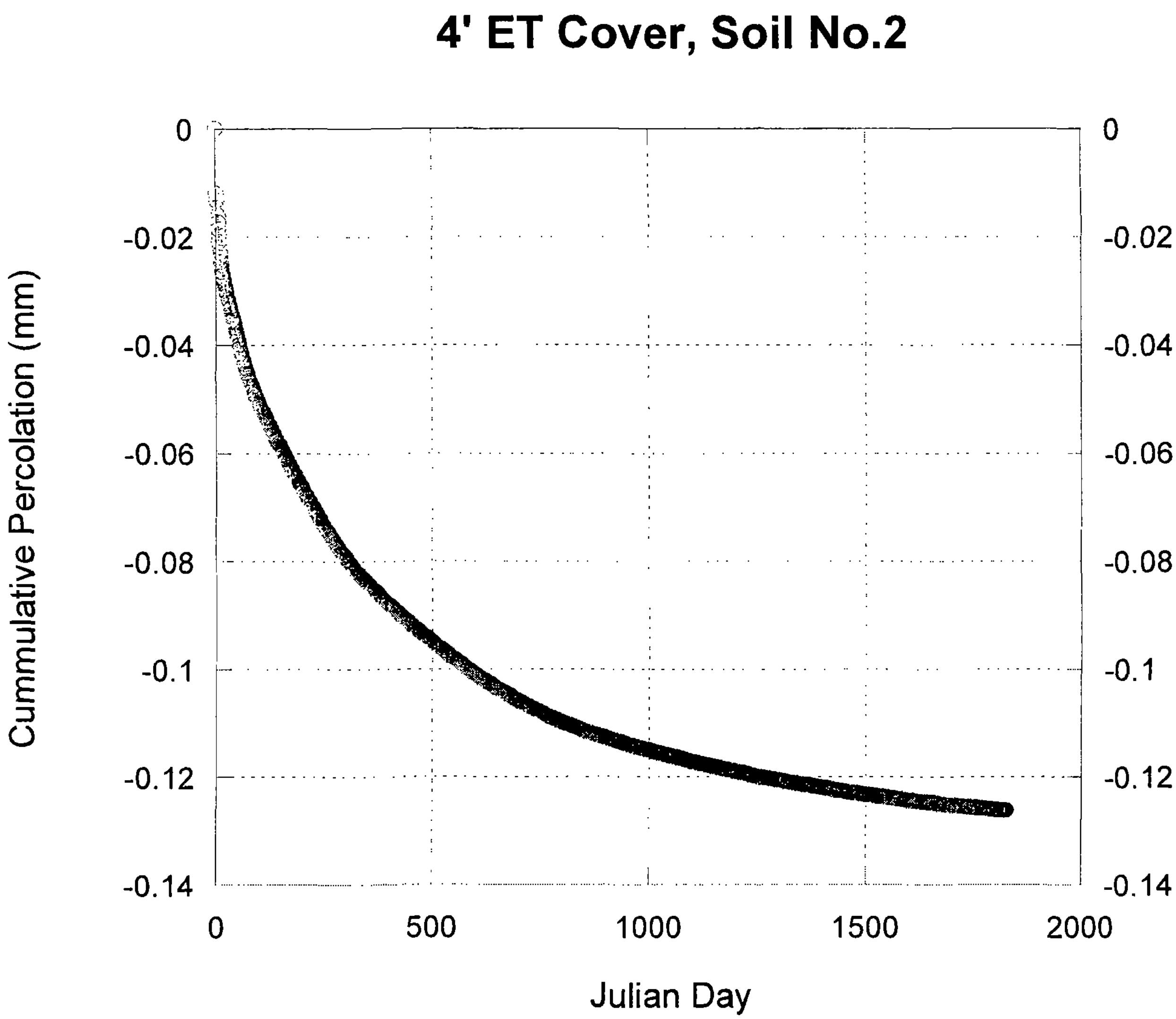


3' ET Cover, Soil No.2

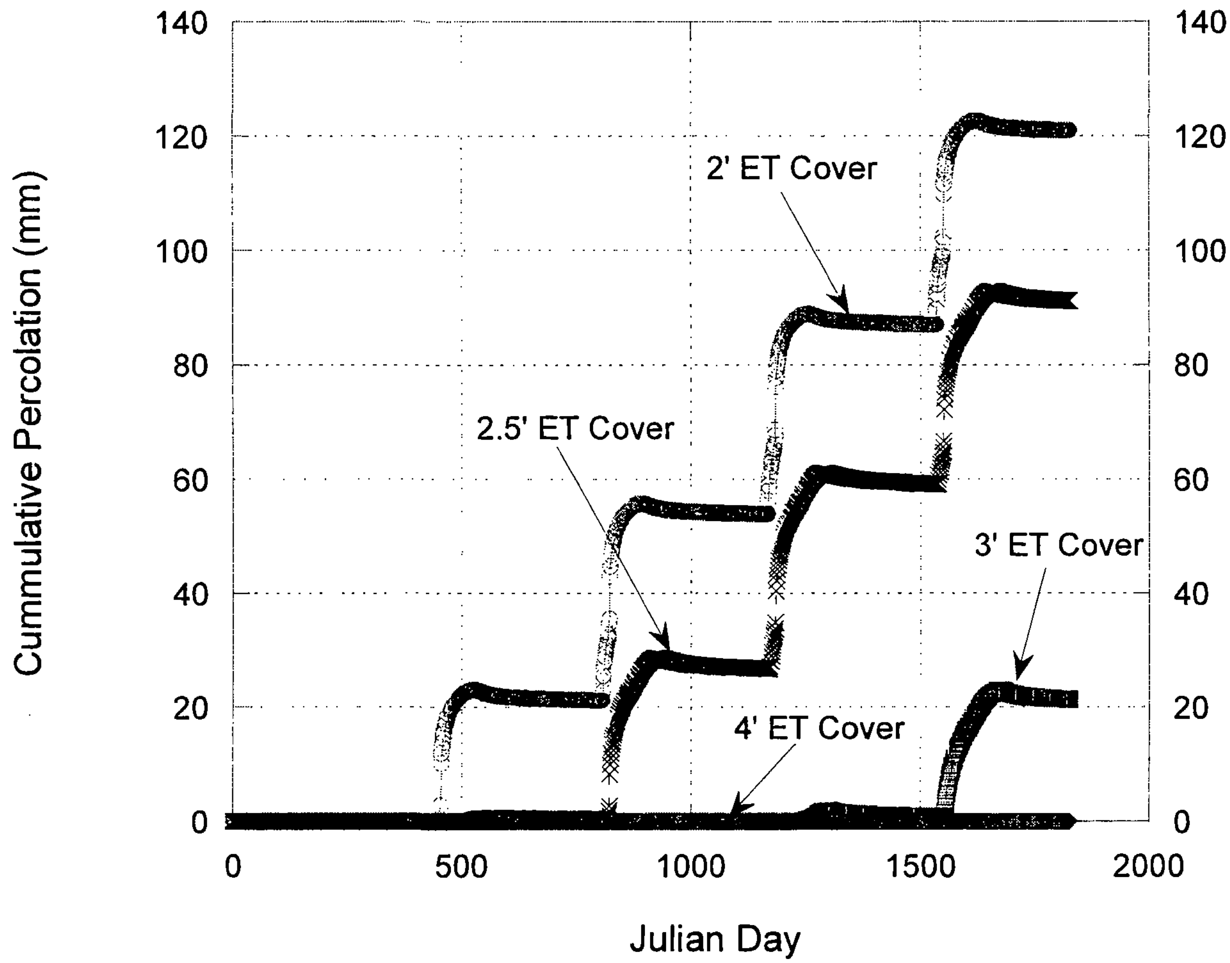


4' ET Cover, Soil No.1

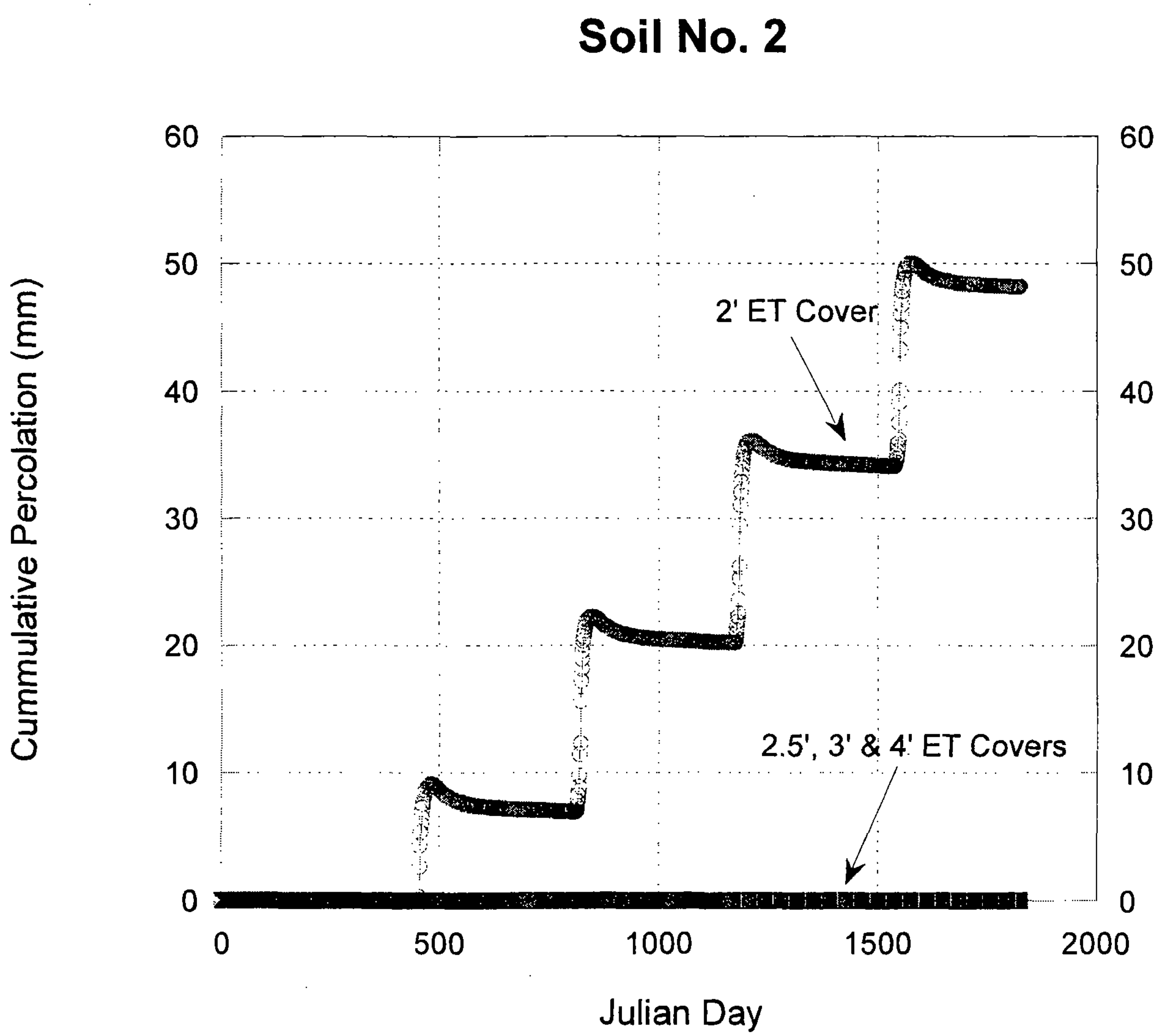



4' ET Cover, Soil No.2
Cummulative Percolation (mm)
Julian Day
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
0
500
1000
1500
2000

Soil No. 1



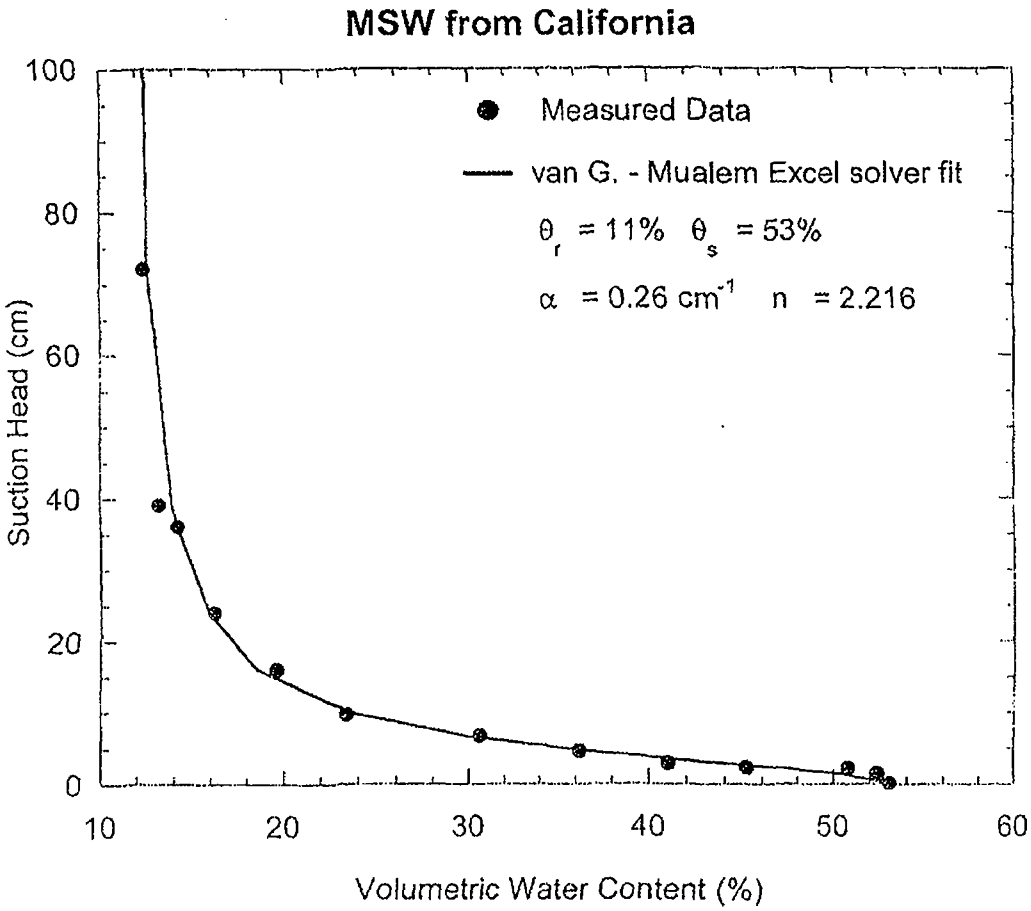
140
120
100
80
60
40
20
0
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
Cummulative Percolation (mm)
Julian Day
2' ET Cover
2.5' ET Cover
3' ET Cover
4' ET Cover



Cover Comparison, Soil No. 2

APPENDIX F
SWCC FOR MUNICIPAL SOLID WASTE

Water Retention Tests on California MSW



APPENDIX 12
COST ESTIMATES FOR CLOSURE & POST-CLOSURE

APPENDIX 12.1
2009 Closure/Post-Closure Cost Certification

VECTOR
ENGINEERING, INC.

February 17, 2009
Project No. 061204.15

Darin Olson
Allied Waste Industries, Inc.
1111 West Hwy 123
East Carbon, Utah 84520

Re: 2009 Certification of Closure and Post-Closure Cost Estimate for the Wasatch Regional Landfill, Utah

At your request, Vector Engineering, Inc. (Vector) has revised the Closure and Post-Closure Cost Estimate for the Wasatch Regional Landfill operated by Allied Waste Industries, Inc. (Allied). This letter is provided to certify that the attached estimates were prepared in accordance with generally accepted civil engineering and waste management practices and in accordance with the requirements of 40 CFR 258.60, Subpart F. It should be noted that no corrective action is anticipated for the site and therefore, no costs for corrective action are provided in the estimates.

The 2009 Closure and Post-Closure Costs were derived after reviewing the previous cost estimates and adjusting the cost spreadsheets based on current data provided by Allied. As you are aware, the changes from the 2008 to 2009 Closure Cost include the increase in the landfill area due to the latest expansion construction.

We hope this provides you with the information you requested. If you have any question regarding the cost estimate, please contact me at your earliest convenience at (530) 272-2448.

Regards,
VECTOR ENGINEERING, INC.

Jake Russell

Jake Russell, P.E., No. 5881834-2202
Senior Engineer

Attachments – Tables 1 through 3

N:\Wasatch/061204.15 Closure-Postclosure 2009/Project Documents\2009 Cost Estimate Certification.doc

Facility: Wasatch Regional Landfill
Feature: *Unit Cost Estimates for Closure and Post Closure Care*
Date: 1/30/2009

TABLE 1
Wasatch Regional
CLOSURE COST ESTIMATES SUMMARY

SIZE OF CLOSURE AREA: 50.7 ACRES

CLOSURE COSTS	MEASURE	UNIT COST		QUANTITY		TOTAL
Supply & Placement of Closure Cap						
General Contractor Mobilization/Demobilization	Lump Sum	$	50,000.00	1	$	50,000.00
Soil Cover (30")	cy	$	3.15	210228	$	662,218.20
Grading of Waste/Surface Preparation	Lump Sum	$	16,375.00	1	$	16,375.00
Surveying	Acre	$	1,950.00	51	$	98,865.00
Grass Erosion Control on Slopes	Acre	$	1,000.00	48	$	47,600.00
Subtotal					**$**	**875,058.20**
Stormwater/Groundwater Controls						
Channel Excavations	LF	$	6.50	3211	$	20,871.50
Riprap Channel Granular Filter (run-on control)	CY	$	45.98	1400	$	64,372.00
Riprap Channel Riprap (run-on control)	CY	$	44.79	2100	$	94,059.00
Downdrain Pipe	LF	$	85.00	805	$	68,425.00
Install Remaining Groundwater Drain (pipe)	LF	$	62.01	3525	$	218,585.25
Install Drain Pipe Under Railroad	Lump Sum	$	102,062.70	1	$	102,062.70
Subtotal					**$**	**568,375.45**
Leachate Evaporation Pond (assume approximately 100' x 100' x 10' deep)						
Pond Excavation/Earthwork	CY	$	2.05	1850	$	3,793.41
GCL	sf	$	0.44	13100	$	5,760.56
60 Mil HDPE Textured, 3-layers	sf	$	1.02	39300	$	40,103.05
Geonet, 2-Layers	sf	$	0.43	26200	$	11,152.67
Leak Detection Pipes and sumps	EA	$	10,000.00	2	$	20,000.00
Subtotal					**$**	**80,809.69**
Other: (List)						
Engineering Site Evaluation	LS	$	7,621.22	1	$	7,621.22
Design, Specification & CQA/CQC Manual	LS	$	38,106.08	1	$	38,106.08
Project Mgmt. & QA/QC, Oversight	LS	$	76,212.17	1	$	76,212.17
Subtotal - Other					**$**	**121,939.47**
TOTAL					**$**	**1,646,182.80**

The cost to install a drain pipe and the cost of an open channel drain from the ground water control system to the canal to the east of the facility is about the same. Assume the pipe cost for financial assurance.

Facility: Wasatch Regional Landfill
Feature: Unit Cost Estimates for Closure and Post Closure Care
Date: 1/30/2009

TABLE 2
AREA OF LINED LANDFILL
POST-CLOSURE COST ESTIMATES SUMMARY

LENGTH OF CLOSURE ACTIVITIES: 30 YEARS

FINAL CLOSURE COSTS					COST/YR	30-YEAR TOTAL
Closure Certification[1][4]					$ 1,594	$ 47,811
MAINTENANCE COSTS[1][4]						
Security, fencing, gates, signs, access, etc.					$ 1,833	$ 54,983
Erosion repair, settlement repair, revegetation					$ 5,312	$ 159,370
Surface water control maintenance (run-on/run-off)					$ 2,656	$ 79,685
Monitoring system maintenance, repair, replacement					$ 1,062	$ 31,874
Leachate collection system, repair, replacement					$ 1,062	$ 31,874
Subtotal					**$ 11,926**	**$ 357,786**
MONITORING COSTS [2][3][4]	**# OF WELLS/PTS.**	**# OF SAMPLES**	**FREQ/ YR**	**COST/ SAMPLE**	**COST/ YEAR**	
Groundwater						
3rd Party/Sample Collection[3]	3	1	2	$ 174	$ 1,042	
3rd Party/Statistical Analysis[3]	1	1	2	$ 781	$ 1,562	
Lab Analysis	3	1	2	$ 382	$ 2,292	
Subtotal					**$ 4,896**	**$ 146,872**
Leachate Analysis						
3rd Party/Sample Collection[3]	2	2	2	$ -	$ -	
Lab Analysis (Bi-Annual for 10 years)	2	2	2	$ 312	$ 1,250	
Subtotal					**$ 1,250**	**$ 37,499**
Landfill Gas						
3rd Party/Operation and Maintenance[3]	15	1	12	$ 159	$ 28,676	
Subtotal					**$ 28,676**	**$ 430,134**
Total for 2008					**$ 48,341**	**$ 1,020,101**

NOTES:

1 - Rates are based on the 2009 costs from the Washington County Landfill
2 - Surface water monitoring costs are not included due to no local surface water sources.
3 - Estimate reflects 3rd party semi-annual sample collection, lab analysis and statistical evaluation. monitoring and facility inspection, conducted together, when appropriate, at an estimated cost of $2,000/event.
4 - All overhead for oversight and record keeping included within unit rates.

Facility: Wasatch Regional Landfill
Feature: Unit Cost Estimates for Closure and Post Closure Care
Date: 1/30/2009

TABLE 3
Wasatch Regional
CLOSURE/POST-CLOSURE CARE COST ESTIMATE

SIZE OF CLOSURE AREA: **50.7 ACRES**		
TOTAL CLOSURE COSTS	$	1,646,182.80
TOTAL POST-CLOSURE COSTS	$	1,020,100.89
TOTAL COST ESTIMATES:	**$**	**2,666,283.69**

NOTES:
1 - Total Costs are reported in 2009 third-party dollars.
2 - Includes a complete gas collection & control system (GCCS).
3 - Corrective actions are currently not anticipated at site.

ST PAUL TRAVELERS

POWER OF ATTORNEY

Farmington Casualty Company
Fidelity and Guaranty Insurance Company
Fidelity and Guaranty Insurance Underwriters, Inc.
Seaboard Surety Company
St. Paul Fire and Marine Insurance Company
St. Paul Guardian Insurance Company
St. Paul Mercury Insurance Company
Travelers Casualty and Surety Company
Travelers Casualty and Surety Company of America
United States Fidelity and Guaranty Company

Attorney-In Fact No. 215221

Certificate No. 000520859

KNOW ALL MEN BY THESE PRESENTS: That Seaboard Surety Company is a corporation duly organized under the laws of the State of New York, that St. Paul Fire and Marine Insurance Company, St. Paul Guardian Insurance Company and St. Paul Mercury Insurance Company are corporations duly organized under the laws of the State of Minnesota, that Farmington Casualty Company, Travelers Casualty and Surety Company, and Travelers Casualty and Surety Company of America are corporations duly organized under the laws of the State of Connecticut, that United States Fidelity and Guaranty Company is a corporation duly organized under the laws of the State of Maryland, that Fidelity and Guaranty Insurance Company is a corporation duly organized under the laws of the State of Iowa, and that Fidelity and Guaranty Insurance Underwriters, Inc. is a corporation duly organized under the laws of the State of Wisconsin (herein collectively called the "Companies"), and that the Companies do hereby make, constitute and appoint

Donald R. Gibson, Sandra R. Parker, Jacqueline Kirk, Melissa Haddick, and Joe Martinez

of the City of Houston, State of Texas, *their true and lawful Attorney(s)-in-Fact*, each in their separate capacity if more than one is named above, to sign, execute, seal and acknowledge any and all bonds, recognizances, conditional undertakings and other writings obligatory in the nature thereof on behalf of the Companies in their business of guaranteeing the fidelity of persons, guaranteeing the performance of contracts and executing or guaranteeing bonds and undertakings required or permitted in any actions or proceedings allowed by law.

IN WITNESS WHEREOF, the Companies have caused this instrument to be signed and their corporate seals to be hereto affixed, this 5th day of June, 2006.

Farmington Casualty Company
Fidelity and Guaranty Insurance Company
Fidelity and Guaranty Insurance Underwriters, Inc.
Seaboard Surety Company
St. Paul Fire and Marine Insurance Company
St. Paul Guardian Insurance Company
St. Paul Mercury Insurance Company
Travelers Casualty and Surety Company
Travelers Casualty and Surety Company of America
United States Fidelity and Guaranty Company

State of Connecticut
City of Hartford ss.

By: ______________________
George W. Thompson, Senior Vice President

On this the 5th day of June, 2006, before me personally appeared George W. Thompson, who acknowledged himself to be the Senior Vice President of Farmington Casualty Company, Fidelity and Guaranty Insurance Company, Fidelity and Guaranty Insurance Underwriters, Inc., Seaboard Surety Company, St. Paul Fire and Marine Insurance Company, St. Paul Guardian Insurance Company, St. Paul Mercury Insurance Company, Travelers Casualty and Surety Company, Travelers Casualty and Surety Company of America, and United States Fidelity and Guaranty Company, and that he, as such, being authorized so to do, executed the foregoing instrument for the purposes therein contained by signing on behalf of the corporations by himself as a duly authorized officer.

In Witness Whereof, I hereunto set my hand and official seal.
My Commission expires the 30th day of June, 2006.

MARIE C. TETREAULT NOTARY PUBLIC CONNECTICUT

Marie C. Tetreault
Marie C. Tetreault, Notary Public

WARNING: THIS POWER OF ATTORNEY IS INVALID WITHOUT THE RED BORDER

This Power of Attorney is granted under and by the authority of the following resolutions adopted by the Boards of Directors of Farmington Casualty Company, Fidelity and Guaranty Insurance Company, Fidelity and Guaranty Insurance Underwriters, Inc., Seaboard Surety Company, St. Paul Fire and Marine Insurance Company, St. Paul Guardian Insurance Company, St. Paul Mercury Insurance Company, Travelers Casualty and Surety Company, Travelers Casualty and Surety Company of America, and United States Fidelity and Guaranty Company, which resolutions are now in full force and effect, reading as follows:

RESOLVED, that the Chairman, the President, any Vice Chairman, any Executive Vice President, any Senior Vice President, any Vice President, any Second Vice President, the Treasurer, any Assistant Treasurer, the Corporate Secretary or any Assistant Secretary may appoint Attorneys-in-Fact and Agents to act for and on behalf of the Company and may give such appointee such authority as his or her certificate of authority may prescribe to sign with the Company's name and seal with the Company's seal bonds, recognizances, contracts of indemnity, and other writings obligatory in the nature of a bond, recognizance, or conditional undertaking, and any of said officers or the Board of Directors at any time may remove any such appointee and revoke the power given him or her; and it is

FURTHER RESOLVED, that the Chairman, the President, any Vice Chairman, any Executive Vice President, any Senior Vice President or any Vice President may delegate all or any part of the foregoing authority to one or more officers or employees of this Company, provided that each such delegation is in writing and a copy thereof is filed in the office of the Secretary; and it is

FURTHER RESOLVED, that any bond, recognizance, contract of indemnity, or writing obligatory in the nature of a bond, recognizance, or conditional undertaking shall be valid and binding upon the Company when (a) signed by the President, any Vice Chairman, any Executive Vice President, any Senior Vice President or any Vice President, any Second Vice President, the Treasurer, any Assistant Treasurer, the Corporate Secretary or any Assistant Secretary and duly attested and sealed with the Company's seal by a Secretary or Assistant Secretary; or (b) duly executed (under seal, if required) by one or more Attorneys-in-Fact and Agents pursuant to the power prescribed in his or her certificate or their certificates of authority or by one or more Company officers pursuant to a written delegation of authority; and it is

FURTHER RESOLVED, that the signature of each of the following officers: President, any Executive Vice President, any Senior Vice President, any Vice President, any Assistant Vice President, any Secretary, any Assistant Secretary, and the seal of the Company may be affixed by facsimile to any power of attorney or to any certificate relating thereto appointing Resident Vice Presidents, Resident Assistant Secretaries or Attorneys-in-Fact for purposes only of executing and attesting bonds and undertakings and other writings obligatory in the nature thereof, and any such power of attorney or certificate bearing such facsimile signature or facsimile seal shall be valid and binding upon the Company and any such power so executed and certified by such facsimile signature and facsimile seal shall be valid and binding on the Company in the future with respect to any bond or understanding to which it is attached.

I, Kori M. Johanson, the undersigned, Assistant Secretary, of Farmington Casualty Company, Fidelity and Guaranty Insurance Company, Fidelity and Guaranty Insurance Underwriters, Inc., Seaboard Surety Company, St. Paul Fire and Marine Insurance Company, St. Paul Guardian Insurance Company, St. Paul Mercury Insurance Company, Travelers Casualty and Surety Company, Travelers Casualty and Surety Company of America, and United States Fidelity and Guaranty Company do hereby certify that the above and foregoing is a true and correct copy of the Power of Attorney executed by said Companies, which is in full force and effect and has not been revoked.

WARNING: THIS POWER OF ATTORNEY IS INVALID WITHOUT THE RED BORDER

***IN TESTIMONY WHEREOF**, I have hereunto set my hand and affixed the seals of said Companies this* 8th day of June, 20 07

Kori M. Johanson, Assistant Secretary

To verify the authenticity of this Power of Attorney, call 1-800-421-3880 or contact us at www.stpaultravelersbond.com. Please refer to the Attorney-In-Fact number, the above-named individuals and the details of the bond to which the power is attached.

Travelers

RIDER

To be attached to bond known as Bond No. 104569268

issued by TRAVELERS CASUALTY AND SURETY COMPANY OF AMERICA

(as Surety), in the amount of $4,127,047.00 effective August 22, 2005

on behalf of Wasatch Regional Landfill, Inc.(as Principal) in favor of

Executive Secretary of the Solid and Hazardous Waste Control Board of the State of Utah(as Obligee)

In consideration of the premium charged for the above bond, it is mutually understood and agreed by the Principal and the Surety that:

THE PENALTY OF THIS BOND IS HEREBY DECREASED AS FOLLOWS:

From: Closure : $2,211,547.00
Post Closure : $1,915,500.00
Total: $4,127,047.00

To: Closure : $1,752,553.00
Post Closure : $1,945,500.00
Total: $3,698,053.00

All other terms, limitations, and conditions of said bond except as herein expressly modified shall remain unchanged.

This rider shall be effective as of the 8th day of June, 2007.

Signed, sealed and dated the 8th of June, 2007.

Wasatch Regional Landfill, Inc.

By JLWhite
Jo Lynn White, Secretary

TRAVELERS CASUALTY AND SURETY COMPANY OF AMERICA

By Melissa Haddick
Melissa Haddick, Attorney-in-Fact

State of Utah
JON M. HUNTSMAN, JR.
Governor
GARY HERBERT
Lieutenant Governor

Department of
Environmental Quality
William J. Sinclair
Acting Executive Director
DIVISION OF SOLID AND
HAZARDOUS WASTE
Dennis R. Downs
Director

February 25, 2009

Darin Olson
Allied Waste
P.O. Box 69
East Carbon, Utah 84520

Subject: Wasatch Regional Landfill 2008 Solid Waste Report
(Tracking *#09.00652*)

Dear Mr. Olson:

The Division has received the 2009 Certification of Closure and Post-Closure Cost Estimates for the Wasatch Regional Landfill provided by Vector Engineering, Inc. that was included in the 2008 annual report.

The Division has reviewed the detailed spreadsheet Tables 1, 2 and 3 for the Closure and Post-Closure Cost estimates for the 50.7 acres presently developed. The cost estimates as submitted have been determined complete and are approved.

Please contact Rob Powers or Ralph Bohn, with the Solid Waste Section, at 801-538-6170 if you have any questions.

Sincerely,

Dennis R. Downs, Executive Secretary
Utah Solid and Hazardous Waste Control Board

DRD/rdp/kk

c: Myron Bateman, E.H.S., M.P.A., Health Officer, Tooele County Health Department
Kirk Treece, Allied Waste
Kim Higgins, State of Utah School and Institutional Trust Lands Administration

TN200900232.DOC

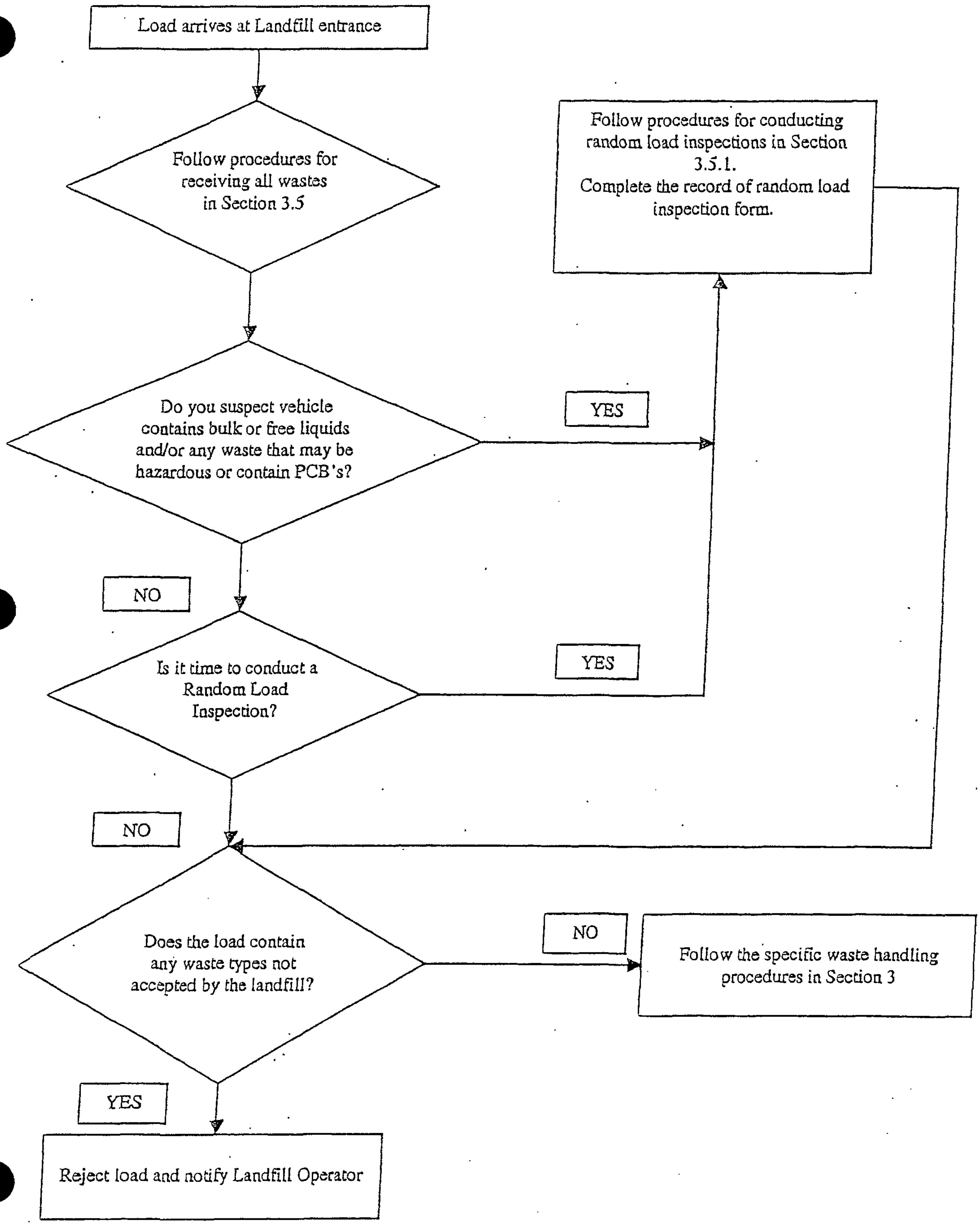
APPENDIX 13
PLAN OF OPERATIONS

APPENDIX 13.1
Waste Handling Procedure Overview

APPENDIX 13-1

Waste Handling Procedure Overview

Waste Handling Procedure Overview



APPENDIX 13.2
Regular Inspection Form

APPENDIX 13-2

Regular Inspection Form

Wasatch Regional Landfill
Regular Inspection Form

Area of Inspection	Compliance Status Yes/No/NA			Comments or Corrective Action
General Inspection Items				
Litter control/wind blown debris maintained				
Integrity of closed/covered fill areas				
Public health/environment safety				
Required P.P.E. available and fully stocked				
Waste sufficiently compacted				
Minimum 6" soil or ADC applied				
Proper intermediate cover				
Fences and signs maintained				
Random inspections for hazardous waste performed				
Only authorized vehicles are allowed on site				
Approved waste handling procedures followed				
Proper dust control				
Properly maintained roads				
Minimizing active working face				
Boundary posts are clearly visible				
Landfill sign provides correct hours of operation, a list of prohibited waste, and a current emergency phone number				
Gates locked and site secure after hours				
Vector control				
Confinement of active area				
No exterior slope leachate seeps				
Appropriate open burning				
No unauthorized waste				
Maintenance of monitoring devices				
Maintenance of site roads in active areas				
Maintenance of vegetative cover				
In compliance with approved phasing plan for landfill development, gas system installation, and closure				
Gas extraction system operation				
Proper Operating Records				
Integrity/protection of liner				
Proper maintence/protection of groundwater monitoring wells				
Maintenance/monitoring of leachate system				
Stormwater Inspection (refer to SWPPP for details)				
Run-on /Run-off Control Measures				
Vehicle and equipment maintenance areas				
Vehicle and equipment parking and storage				
Wash area				
Aboveground liquid storage				
Oil/water separators				
BMPs/other				

Wasatch Regional Landfill
Regular Inspection Form Continued

Area Of Inspection	Compliance Status Yes/No/NA			Comments or Corrective Action
Spill Prevention and Control (refer to SPCCP for details)				
Condition of tanks, valves, seals, and gaskets				
Signs of oil, fuel, or chemicals in fueling area or containment				
Condition of container supports and foundations				
Date:	**Name(printed and signed):**			
Additional Comments:				

LOAD INSPECTION FORM

Date: __________ Time: __________

Hauler Information:

Company Name: ____________________

Driver's Name: ____________________

Truck Number: ____________________

Plate Number: ____________________

Waste Source: ____________________

Physical Inspection of the Load:

The inspector must check the following:

The load was discharged within a separate area of the facility and unloading of the entire load's contents was observed. ________

There is no evidence of regulated hazardous wastes (i.e., drums containing hazardous waste labels, PCB wastes, sludges, other industrial process wastes) or evidence of other unacceptable materials (i.e., asbestos). ________

There was no evidence of potentially infectious medical waste (i.e., red bagged material, syringes, etc.). ________

Note: If it is discovered that there is evidence of unacceptable waste materials within the load, such information must be provided in detail on the reverse side, and the site manager must be notified. All action taken to address the situation must also be reported on the reverse side.

____________________ ____________________

Inspector's Name Signature

APPENDIX 13.3
Daily Operating Record

APPENDIX 13-3

Daily Operation Record

Wasatch Regional Landfill Daily Operating Record

Week Ending:	Mon	Tue	Wed	Thur	Fri	Sat	Total
Weather notes:							
Have there been any deviations from the Plan of Operation? (Y/N)							
Cell Operations:							
Total Tons Waste							0
Cubic yards of waste							0.00
Daily Cover Loads Hauled							0
Daily Cover Cubic Yards							0
Temporary Intermediate Cover Loads Hauled							0
Temporary Intermediate cubic yards							0
Long-term Intermediate Cover Loads Hauled							0
Long-term Intermediate Cover cubic Yards							0
Tipper Pad/Cell Roads Loads Hauled							0
Tipper Pad/Cell Roads Cubic Yards							0
Protective CoverLoads Hauled							0
Protective Cover Cubic Yards							0
Other Loads(Outside Cell) Hauled							0
Other Cubic Yards							0
Total Loads Hauled	0	0	0	0	0	0	0
Time Spent Hauling							0
# Operators Hauling Soil							
Rate/hour							#DIV/0!
Type of cover used							
Condition of Cell Roads							
Condition of Other Haul Roads							
Equipment Hours Operated							
D8T Dozer (D2)							0
D8R Dozer (D3)							0
836H Compactor (C2)							0
836H Compactor (C3)							0
836G Compactor (C4)							0
140G Motor Grader (G1)							0
Autocar Water Truck (W1)							0
John Deere Excavator (E1)							0
John Deere Articualted Dump Truck (R1)							0
Total Equipment Hours	0	0	0	0	0	0	0
Number of Operators							0
Hours Worked							0.00
Other Temp Hours							0.00
Litter Control:							
Number of Workers							0
Hours Worked							0.00
Litter Fence Installed (Feet)							0
Daily Fuel Consumption							0.00

Note: Detailed daily waste information, detailed weather conditions, and a description of any deviations from the approved Plan of Operation will be maintained in separate files at the landfill.

APPENDIX 13.4
Training and Safety Plan

APPENDIX 13-4

Training and Safety Plan

Training and Safety Plan

Orientation and Training

The Manager will conduct an orientation program to familiarize employees with the organization and to train employees for their new position.

The manager is responsible for the overall development and coordination of the orientation program and for implementing the portions of it that cover policies, benefits, and new employee files and documentation. Each supervisor is responsible for orientation as it applies to introducing the new employee to the job and the department and may select a coworker to serve as a sponsor to facilitate the new employee's transition.

The manager will maintain records of all training programs completed by each employee. The annual training schedule will include al items below.

- Solid Waste Permit Requirements
- Operations Plan
- Waste arrival and unloading procedures
- Employee Right to Know
- Respirator Training
- Emergency Response and Spill Procedures
- Identification of Unacceptable / Hazardous Waste
- Lock-out / Tag-out
- Forklift Review
- Confined Space
- Asbestos Management
- Blood Borne Pathogens
- Electrical Safety
- Drug and Alcohol Awareness / Need to Know
- Personal Protective Equipment
- Storm Water Plan
- Spill Plan

APPENDIX 13.5
Litter Control Plan

APPENDIX 13-5

Litter Control Plan

Litter Control Plan

Litter Control

The facility management will make every effort to clean the entire site, access and entrance roads as well as the geographic area around the site, of any windblown litter by sundown of each operating day. If this is not possible, litter pickup will begin immediately the following day and continue until the geographic area and the facility have been completely cleared of litter. Facility management will continue to evaluate the litter until such time as the facility is clean. All plastic bags that are filled with litter will be picked up and properly disposed of at the end of the day. Bags of litter should not be allowed to sit on or around the facility overnight.

High Wind Situations

If high wind situations are encountered, facility management will reduce the size of the tipping face as much as possible. Operational considerations, such as reduction of the tipping face, reduction of the number of vehicles allowed to discharge their loads at one time and discharge of loads into the wind will also be used. Facility management will monitor the number of trucks which are allowed to discharge their loads at one time in order to allow compaction equipment to compact the waste streams faster and more efficiently. Third party companies will be required to untarp their loads only when they are arrive at the tipping face. In addition, if at all possible the tipping face will be reconfigured so that discharging vehicles are dumping their loads into the oncoming high winds, vehicles will not be allowed to discharge their loads down wind. Should the high winds present situations that the windblown litter cannot be controlled, then facility management will evaluate the options of closing the landfill for the day. Facility closings will be requested only in extreme high wind situations.

Temporary Fencing

Temporary fencing to surround general disposal operations will be used as needed. All temporary fencing will be cleaned of litter regularly. The need for temporary fencing will be evaluated by facility management, based on weather conditions and current, future cell operations, additional fencing will be installed as needed.

Litter Pickers

Weather reports will be monitored daily and if high winds are expected, the temporary service company will be contacted the prior day to allow them reasonable time to find workers. The number of workers will be closely evaluated by facility management to assure that the windblown trash will be picked up within a reasonable time frame.

Temporary service workers will be managed and directed by facility personnel. Temporary service workers will focus on one section of the facility at a time. When that section has been adequately cleaned, move them to a second section.

The basis of this plan will be to insure that the facility continues to monitor windblown trash throughout the day and that appropriate action is taken to reasonably maintain the facility.

APPENDIX 13.6
Fugitive Dust Control Plan

APPENDIX 13-6

Fugitive Dust Control Plan

Fugitive Dust Control Plan

Introduction

This plan has been developed in order to address the measures and methods for controlling on-site fugitive dust resulting from normal operations at the Wasatch Regional Landfill. It is the intent of this report to provide control strategies for the minimization of fugitive dust emissions as required by Utah Code Rule R307-205 and the Utah Division of Air Quality.

The landfill is owned and operated by Wasatch Regional Inc. The general site location, shown in Figure 1, is roughly 6 miles north of Interstate 80 in Tooele County in an unpopulated section of the county, north/northwest of Grantsville and south of Rowley. The site property is currently owned by the Utah State Institutional Trust Lands Administration (SITLA) and WRL. WRL has entered into a ground lease agreement with SITLA in order to operate the facility.

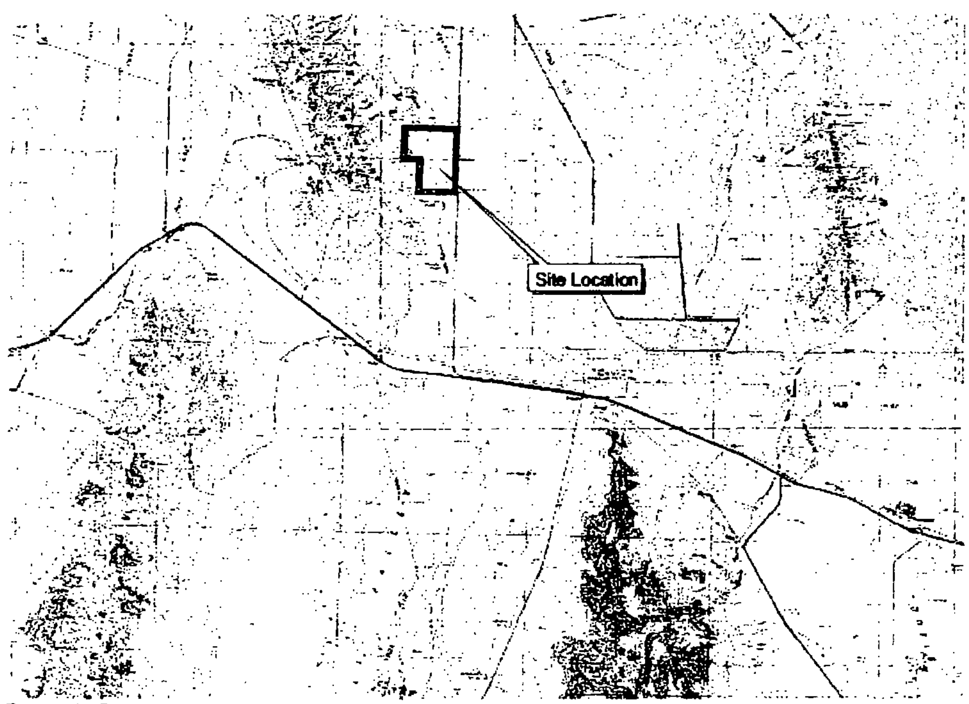


Figure 1. General site location.

There are no residences within several miles of the Wasatch landfill site and the adjacent parcels are all vacant and undeveloped. A rail spur and County Road 128 on the east side of the parcel are the only uses adjacent to the site. The site is approximately 1,969 acres in size, which is sufficient to handle incoming waste projected over several decades.

The Wasatch landfill site, shown in more detail in Figure 2, is located in Sections 3 and 4 of Township 1 North, Range 8 West; and Sections 32, 33, and 34 of Township 2 North, Range 8 West Salt Lake Base & Meridian. The site covers approximately 1,969 acres, more or less. The legal description of the site is as follows:

> *All of Section 33, the west ½ of Section 34, and the east ½ east ½ of Section 32 of Township 2 North, Range 8 West, Salt Lake Base & Meridian. Lots 3 and 4, the south ½ northwest ¼ and southwest ¼ of Section 3, and Lots 1, 2, and 3, southeast ¼ northwest ¼, east ½ southwest ¼, southeast ¼, south ½ of northeast ¼ of Section 4, Township 1 North, Range 8 West, Salt Lake Base & Meridian.*

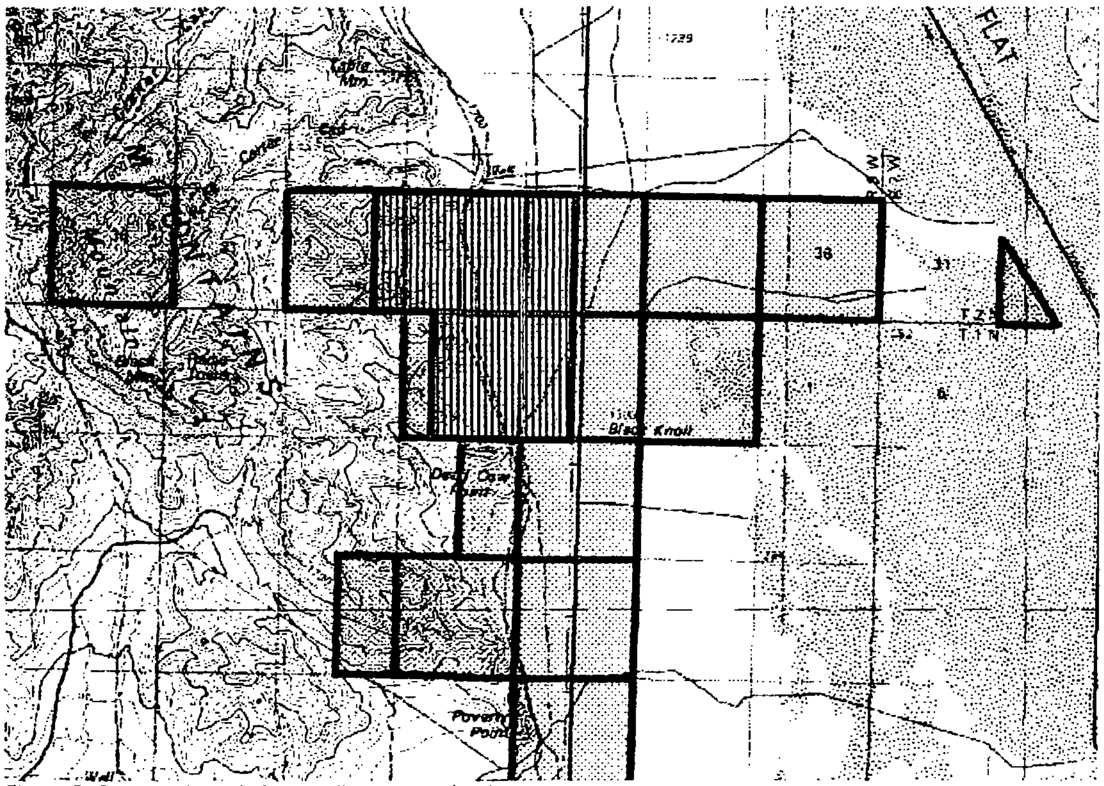


Figure 2. Site location relative to adjacent trust lands.

Fugitive Dust Emission Sources

Windblown dust occurs both from natural and man-made sources. While dust is common for the undisturbed areas in the West, it becomes much more common where the natural soils have been disturbed by construction and operational activities. During normal facility operations, several sources of fugitive dust emissions are possible. In addition to normal waste handling procedures, at certain times during the lifetime of the facility portions of the facility will be under expansion construction. The types of materials that potentially emit fugitive dust are non-hazardous waste material, on-site soil (silts and sands), due to construction. The activities that may result in fugitive dust emissions are, but not limited to:

- landfill operating haul road traffic
- gravel/dirt road traffic
- waste unloading operations
- waste compaction
- soil excavation
- soil stockpiling
- soil spreading
- soil screening
- expansion construction

Fugitive Dust Mitigation and Control Measures

According to Utah Code Rule R307-205-2 fugitive emissions from sources constructed after April 25, 1971, shall not exceed 20 percent opacity. The percent opacity will be determined either by observations made by a qualified operator or by opacity/dust monitors.

The Wasatch Regional Landfill will implement, on an as needed basis, an appropriate combination of the following mitigation measures in order to prevent and control fugitive dust emissions:

- Water spray from an on-site water truck, misting systems, or sprinklers can be used to effectively reduce and prevent fugitive dust emissions. Water will be used as a dust suppressant in all areas of the landfill including soil stockpile areas. The site operator must use appropriate amounts of water in order to control fugitive dust emissions, and minimize excess amounts of water which may create mud. Watering during winter months may freeze and cause equipment and safety concerns.

- Paving represents the most efficient way of controlling fugitive dust emissions. The main road into the landfill facility and east of the landfill is paved. Additional pavement will be placed as future permanent haul roads are constructed.

- Paved road cleaning with vacuum street cleaning equipment, washing or scraping at regular intervals.

- Track-out controls - reducing dirt tracked from unpaved haul roads and construction areas, using paved or gravel entry aprons and/or devices such as steel grates that are capable of knocking mud and bulk dirt off vehicle tires.

- Trucks hauling non-hazardous waste, soil and construction materials, and other items to or from the site, should be fully covered and have secured cargo loads to prevent leakage from truck beds, sideboards, tailgate, or bottom dump gate.

- Applying chemical dust suppressants. Chemical dust suppressants can be widely applied on paved and unpaved roads, on exposed and disturbed areas of the landfill, and on graded sloped surfaces. Chemical dust suppressants should be applied in amounts and rates as recommended by the manufacturer. Some chemical dust suppressants have significant performance limitations in arid and semi-arid climates, these limitations should be accounted for when choosing the chemical dust suppressant.

- Applying gravel to unpaved roads and areas of exposed soil minimizes dust emissions. It is important that the gravel applied contains minimal amount of fines as they have a tendency to migrate to the surface and become a source of airborne dust.

- Reducing vehicle speed – the maximum vehicle speed in unpaved areas should not exceed 15 miles per hour, or other speed as appropriate to control dust.

- Install temporary windbreaks around the site. This measure is recommended for construction activities and limited to smaller areas. More permanent windbreaks can be achieved by planting bushes and trees, and constructing earthen banks and rock walls.

- Slow or stop waste handling procedures (waste unloading, compaction, daily cover), and construction activities during high wind events (wind speeds 20-25 miles per hour). An on-site anemometer could be installed to measure wind speed and alert the landfill personnel.

- Phase construction, soil clearing and stabilization in a manner that will minimize the length of time and the amount of exposure of unstable soil.

- Use geotextiles and/or revegetation techniques on graded sloped surfaces to prevent wind and water erosion.

- Cover disturbed and exposed areas with rock, geotextiles, bark, hay (crimped into the surface), or other organic mulch.

- Re-vegetate areas no longer used (closed cell areas) by planting or seeding. Xeriscaping (using plants that require little or no additional water) should be considered, given the importance of water conservation and the regional arid climate.

- In properly lined areas (within cells), recirculated leachate can be used as a dust suppressor during waste compaction, unloading, and waste covering activities.

- Vehicle traffic over non-paved areas can be a source of significant dust. Staging areas can be set up to limit the distance vehicles must travel over non paved areas.

- Whenever possible, dry and wet waste material should be mixed, during the loading of the haul vehicles.
- Proper tire pressure should be maintained in all vehicles operated at the landfill.
- Prompt clean up of accidental spills ensures that the spill does not become a fugitive dust emission source.

APPENDIX 13.7
Groundwater Monitoring Plan

APPENDIX 13-7

Groundwater Monitoring Plan

GROUNDWATER SAMPLING AND ANALYSIS PLAN (GWSAP)

WASATCH REGIONAL LANDFILL
TOOELE COUNTY, UTAH

Project No: 05-04-09

Prepared for

Wasatch Regional Landfill

April 2005

Revised August 2005

Prepared by:

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1 INTRODUCTION

The following sampling and analysis plan covers the procedures for collecting representative samples from groundwater monitoring wells and the laboratory requirements for obtaining valid, defensible data. The scope is limited to sampling and analysis requirements and does not include monitor well placement, design and construction, or well development procedures.

The plan is a general requirement for groundwater monitoring sampling and analysis based primarily on the federal requirements in 40 CFR Part 258, current EPA guidance documents, and Utah Administrative Code (UAC) R315-308-2 Solid Waste Permitting and Management Rules.

2 FIELD PROCEDURES

2.1 Field Sampling Health and Safety Plan

A health and safety plan is required for all groundwater sampling events at the Wasatch Regional Landfill. Prior to monitoring well purging and sampling, the sampling contractor's Groundwater Sampling Health and Safety Plan must be in place. Designing the site Groundwater Sampling Health and Safety Plan will be the duty of the party performing the actual work.

In addition, each laboratory facility should have their own standard laboratory health and safety plan as required by current OSHA regulations.

2.2 Sample Event Preparation and QA/QC

2.2.1 General Event Preparation

The laboratory performing the groundwater analysis shall supply all necessary coolers, pre-cleaned containers, trip blanks, chemical preservatives, labels, custody seals, and chain-of-custody and shipping forms. All field data shall be entered on a Field Data Sheet (see example provided as Appendix A) or equivalent form. Adequate instructions to the laboratory must be given in advance of each monitoring event. Details concerning any changes to the monitoring plan and/or procedures need to be given to the laboratory prior to the field sampling personnel arriving on the site. A specific contact person shall be established at both the facility and contract laboratory for communication between the two (2) parties.

2.2.2 Sample Container Selection

Sample containers need to be constructed of a material compatible and non-reactive with the material it is to contain. Consult Appendix B, *Recommended Containerization and Preservation of Samples*, to determine the number, type and volume of appropriate containers. As noted in Section 2.1.1, the contract laboratory performing the analysis shall supply all the required containers. In special circumstances when the facility must obtain its own containers, these containers will be purchased from local container distributors with the exception of the septum vials and PTFE (e.g. Teflon®) lined caps required for organic analyses which are available from laboratory supply companies. Metal lids shall not be utilized for any sample containers.

2.2.3 Container Preparation

Sample containers will be purchased as a pre-cleaned product or cleaned in the laboratory in a manner consistent with EPA protocol.

2.2.4 Sample Equipment Preparation

This section outlines the equipment preparation prior to site arrival for a specific monitoring event. This equipment preparation includes minimum decontamination procedures for water level indicator(s), pH/temperature meter, specific conductivity meter, turbidity meter, and filtration device. Operation and calibration of equipment will be as per the manufacturer's instructions. All non-dedicated equipment will be thoroughly cleaned prior to arrival at the site and between sampling points as follows:

- Water Level Indicator(s) - Water level indicator(s) will be decontaminated prior to initial site arrival by hand washing the sensor probe and entire length of tape in a non-phosphate detergent followed by rinsing with organic free water. While the tape is reeled back onto the carrying spool, the tape and probe will be wiped down with a clean dry paper towel.

- Field Parameter (Temperature, pH, Specific Conductivity, Turbidity) Measuring Device(s) – Field parameter measuring device(s) will be decontaminated by hand washing the sample cells in a non-phosphate detergent followed by rinsing with deionized water. Meters will then be checked for proper calibration and operation as per the manufacturer's instructions. Any malfunctioning meters will be replaced prior to packing. Field parameter measuring device(s) will be rinsed with deionized water after each measurement.

- Sampling devices associated with groundwater sampling will be cleaned in non-phosphate detergent, followed by rinsing with deionized water.

Multiple-use equipment (e.g. water level indicators and filter chambers) must be thoroughly decontaminated and cleaned as described in this section to prevent cross contamination from prior use at other facilities. All field instruments must be properly checked and calibrated prior to arrival on-site at a sampling location.

2.2.5 Field QA/QC Samples

Field QA/QC samples consist of two (2) primary areas of quality control. The first part is the quality control of sample contamination, which may occur in the field and/or shipping procedures. This is monitored in the trip blank(s), field blank(s), and the equipment (rinsate) blank(s). A basic description of each is as follows:

- Trip Blank - These samples will be prepared in the laboratory by filling the appropriate clean sample containers with organic-free water and adding the applicable chemical preservative, if any, as indicated in Appendix B for each type of sample. These containers are to be labeled "Trip Blank", the analyses to be performed on each container indicated, and then shipped in the typical transportation cooler to the field and back to the laboratory along with the other sample set containers for a given event. This blank is tested for any contamination that may occur as a result of the containers, sample coolers, cleaning procedures, or chemical preservatives used. Trip blanks shall be taken and analyzed for each sampling event or a minimum of a one (1) in twenty (20) batch per monitoring event for volatile organic compounds (VOCs).

- Field Blank - Field blank containers will be prepared in the field at a routine sample collection point during a monitoring event by filling the appropriate sample containers from the field supply of organic free water. This field supply water shall be the same water used for cleaning and decontamination of all field purge and sample equipment. This blank is tested for any contamination that may occur as a result of site ambient air conditions and serves as an additional check for contamination in the containers, sample transport coolers, cleaning procedures, and any chemical preservatives. Field blanks shall be taken and analyzed for each sampling event or a minimum of a one (1) in twenty (20) batch per monitoring event for VOCs.

- Equipment (Rinsate) Blank - These blanks will be prepared in the field immediately following decontamination cleaning procedures on any non-dedicated equipment used for purging, sampling or sample filtration. Following decontamination, field supply organic-free water is passed through the non-dedicated equipment in the same procedure as a groundwater sample. This blank confirms proper field decontamination procedures on non-dedicated equipment utilized in the field. Equipment blanks shall be taken and analyzed for all applicable parameters anytime non-dedicated equipment is used or new equipment is being dedicated to a well at a batch minimum of one (1) in twenty (20) per monitoring event.

Other Field QA/QC Samples - A second area of standard field QA/QC samples are field duplicates.

- Field duplicates are an extra set of samples taken at a particular monitoring point and labeled "Field Duplicate". These are independent samples that are collected as close as possible to the same point in space and time. They are two (2) separate samples taken from the same source, stored in separate containers, and analyzed independently. Field duplicates are useful in documenting the precision of the sampling and analytical process. Samples shall be collected in proper alternating order for the sample point and field duplicate for each parameter (e.g. VOA - VOA, metals - metals, etc.) Field duplicates shall be taken and analyzed at a batch minimum of one (1) in twenty (20).

Appropriate field QA/QC documentation should be recorded in the field notes (e.g. locations where the field blank or duplicate were collected).

2.3 Well Purge

2.3.1 General Well Purge Information

Purging a monitoring well is just as important as the subsequent sampling of the well. Water standing in a monitor well over a certain period of time may become unrepresentative of formation water because of chemical and biochemical changes which may cause water quality alterations. Prior to monitoring well purge, inspection of the monitoring well integrity will be performed utilizing the Field Data Sheet (Appendix A) or equivalent form.

2.3.2 Water Level Measurement

Prior to any purge or sampling activity at each monitoring well, a water level measurement is required to be taken. Measurement of the static water level is important in determining the hydrogeologic characteristics of the subsurface (e.g. upgradient and downgradient). The water level indicator will be an electronic sensor device, which signals by audio or light indicator when the probe contacts the water.

Water level indicator equipment will be constructed of chemically inert materials and, during mobilization preparation and following each monitoring point, be decontaminated with a non-phosphate detergent followed with multiple deionized water rinses. Water levels will be measured with a precision of +/- 0.01 foot. Water level indicator devices will be periodically checked for proper calibration. Each monitor well shall have a reference elevation point located and properly marked at the top of the riser casing established by a licensed surveyor. This reference point elevation is measured in relation to Mean Sea Level (MSL).

Ground water elevations in wells that monitor the same waste management area must be measured within a forty-eight (48) hour period to avoid temporary variations in groundwater flow, which could preclude accurate determination of groundwater flow rate and direction.

2.3.3 Purge Equipment and Procedure

Well purging will take place from hydraulically upgradient wells to hydraulically downgradient wells. If known impacts exist, purging will take place from the least impacted well to the most impacted well. Prior to purge, the sample personnel will put on clean disposable nitrile gloves and an initial water level will be taken as described in Section 2.3.2.

Groundwater wells will be purged with dedicated bladder pumps. These pumps will remain dedicated to each respective well throughout monitoring unless replacement is necessary due to damage or wear, in which case repairs will be completed or a new pump will be dedicated. Purge procedures for dedicated equipment are described in Section 2.3.3.1. Pump intakes will be located as close as possible to the middle of the screened interval.

2.3.3.1 Dedicated Equipment

Low-flow purging will be employed using dedicated bladder pumps. Well purging will be conducted at a rate of approximately 100 milliliters per minute until a minimum of two pump and tubing volumes have been removed and stabilization of field parameters is achieved. Field parameters include temperature, specific conductivity, pH, and turbidity.

- Parameter stabilization is defined as:
    - Specific Conductivity = ± ~~10~~ 3% for three (3) consecutive measurements
    - pH = ± ~~0.2~~ 0.1 standard pH units for three (3) consecutive measurements
    - Temperature = ± 10% for three (3) consecutive measurements
    - Turbidity = ± 10% for three (3) consecutive measurements

Measurements will be recorded on the field data sheet every three to five minutes. Water level measurement will also be taken every three to five minutes and recorded on the field data sheet. An initial decrease in water level may be expected due to pump and tubing evacuation, however, no subsequent continuous drawdown is to be expected. Should a well repeatedly not meet one or more criteria, alternate criteria may be implemented with UDEQ approval.

A bladder pump will be used for both well purging and sample collection.

Equipment:

- Bladder pump
- Bladder pump controller
- Compressed air source
- New disposable gloves of appropriate material (nitrile)
- Graduated pail and/or cylinder
- Field parameter measurement device/s

Procedure:

- Appropriate disposable gloves are to be worn during installation.
- Connect the compressed air source to the pump fitting at the top of the well.
- Start the air compressor.
- Replace disposable gloves after handling the compressor.
- Turn on the pump controller and adjust the discharge and refill cycles to the appropriate settings.
- Press the start button on the controller, which begins the pumping action.
- Adjust the controller to the desired flow rate (approximately 100 milliliters per minute).

Continue pumping until the necessary volume of water (two pump and tubing volumes minimum) has been purged from the well and field parameters have stabilized.

2.3.3.2 Non-Dedicated Equipment

In the event of a non-operative dedicated pump, the pump and tubing apparatus will be removed for repairs or replacement and the well will be purged by means of either a disposable bailer or a portable pump until such time the bladder pump is repaired/replaced and rededicated to the well. Purging will be performed by removing three well-casing volumes of water from the well or until stabilization of field parameters (as defined in Section 2.3.3.1) occurs. Purging will be deemed complete if the well goes dry before three well-casing volumes of water have been removed. Field parameters will be measured after each well-casing volume of water removed.

Equipment:

- Non-dedicated pump/bailer
- Pump controller (if required)

- Generator or other power source/driving mechanism for pumps / appropriate disposable string or rope for bailer, downrigger (optional)
- New disposable tubing
- New disposable gloves of appropriate material (nitrile).
- Graduated pail or other appropriate container.
- Field parameter measurement device(s)
- Container for laboratory grade, nonphosphate soap/reagent-grade deionized water solution
- Container for reagent-grade deionized water rinse

Procedure (Specific operating instructions vary depending on the type of portable pump used. The steps listed below are generalized procedures)

- Don a new pair of gloves.
- Cleanse portable pump/bailer with a non-phosphate, laboratory grade detergent solution followed by an reagent-grade deionized water rinse. Sufficient water should be passed through a non-dedicated pump to ensure proper cleansing.
- Remove gloves worn during cleaning and don a new pair of gloves
- Attach new disposable tubing to pump or new disposable string to bailer.
- Insert pump and tubing/bailer into well.
- Start the portable pump by the appropriate method and adjust flow to desired rate / initiate removal of water from well with bailer. Ensure bailer and string do not touch ground during purging.

When purging with a bailer, introduce bailer into water column slowly (i.e. do not "drop" into water column) to avoid agitation of water in the well and immediate formation area.

Non-dedicated equipment will be constructed of chemically inert materials and will be decontaminated at each well with a non-phosphate detergent followed with a reagent-grade deionized water rinse. Additional cleaning procedures will be performed as deemed necessary.

Rate of discharge and volume purged will be checked periodically with a graduated bucket and/or timer. Field parameter (temperature, pH, specific conductivity, and turbidity) measurements will be recorded after each well volume of water removed during purging.

2.3.4 Purge Water Management

If purge water is known to be historically contaminated or suspect due to prior analytical data, the water shall be stored in appropriate containers until analytical results are available. After review of these analyses, proper arrangements for disposal or treatment of the water shall be made. Otherwise, purge water will be discarded on the ground away from the monitor well area.

2.4 Monitoring Well Sample Collection

2.4.1 General Sample Collection Information

Sampling should take place as soon as purging is complete if the well has sufficient recharge. If the well was purged dry or significant drawdown of the water level exists immediately after purge, the monitor well should be sampled as soon as sufficient water is present for all analytes to be collected. The time interval between the completion of well purge and sample collection normally should not exceed forty-eight hours.

2.4.2 Sample Collection Order

Monitor well sampling at each event shall proceed from the point with the highest water level elevation to those with successively lower elevations unless contamination is known to be present. If contamination is known to be present, samples will be collected from the least to most contaminated wells, to minimize the potential for any cross-contamination. Samples will be collected and containerized according of the volatility of the requested analyses. A specific collection order is as follows:

- Field Parameters (Temperature, pH, Specific Conductivity, Turbidity)
- Volatile Organics
- Metals
- Inorganics

2.4.3 Sampling Equipment/Procedures

Groundwater wells will be sampled using dedicated bladder pumps. These are the same pumps used for well purging.

2.4.4 VOC Sample Collection

Filling VOC sample containers involves extra care. The water should be gently added to each vial until a positive meniscus is formed over the top of the container. This insures no headspace is present in the sample vial upon replacing the cap. After the cap has been placed on the vial and tightened, the vial should be checked for air bubbles by turning upside down and tapping with finger. If a bubble is seen rising to the top of the inverted vial, the process outlined above should be repeated. If no air bubbles are seen in each vial, the process is complete.

2.4.5 Sample Filtration

All efforts must be made to delete or minimize controllable factors to allow the collection of as representative and turbid-free sample as possible. Utah DEQ, UAC, Solid Waste Permitting and Management Rules does not currently allow for field sample filtration of constituents listed in R315-308-4 prior to laboratory analysis (R315-308-2 (4)(d)). The facility may collect samples for laboratory filtration and analysis of dissolved metals when deemed necessary. Otherwise, metal and inorganic indicator analyses will be for total concentrations.

2.4.6 Sample Preservation

All samples will be containerized and preserved according to Appendix B, *Sample Containerization and Preservation.* In the goal to obtain the most representative sample possible, preserving the sample for transportation and storage to the laboratory is also important.

Methods of preservation are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Samples requiring refrigeration to four degrees Centigrade will be accomplished by placing the sample containers immediately into coolers containing wet ice or the equivalent and delivering to the analytical laboratory as soon as possible.

2.4.7 Field Measurements

Required field measurements include water levels, temperature, pH, specific conductivity, and turbidity. Each of these measurements is important in the documentation of properly collected groundwater samples.

All instruments shall be properly calibrated and checked with standards according to the manufacturer's instructions and/or the field crew's standard operating procedures. Any improper operating instruments must be replaced prior to continuing sample collection operations.

2.5 Record Keeping

2.5.1 Field Logs

All field notes must be completely and accurately documented to become part of the final report for a monitoring event. All field information will be entered on a Field Data Sheet (see Appendix A) or equivalent form.

All entries should be legible and made in indelible ink. Entry errors will be crossed out with a single line, dated, and initialed by the person making the corrections.

2.5.2 Chain-of-Custody

Proper chain of custody records are required to insure the integrity of the samples and the conditions of the samples upon receipt at the laboratory, including the temperature of the samples at the time of log in. The sample collector shall fill in all applicable sections and forward the original, with the respective sample(s), to the laboratory performing the analysis. Upon receipt of the samples at the laboratory, the sample coordinator is to complete the chain of custody, make a copy for his/her files, and make the original documents part of the final analytical report (see example provided as Appendix C). All sample containers will be labeled to prevent misidentification. The following will be indicated on an adhesive label with a waterproof pen:

- Collector's name, date and time of sampling.
- Sample source.
- Sample Identification number.
- Sample preservatives.
- Test(s) to be performed on the sample.

Sample shuttle kits (coolers) will employ a tamper proof seal.

2.6 Sample Transport

Samples shall be shipped from the field back to the analytical laboratory either by hand delivery or utilizing an overnight courier service. Samples are to be shipped in sealed insulated shipping containers. Standard shipping containers must be a sturdy waterproof design (ice chests are commonly used) equipped with bottle dividers and cushion material to prevent breakage during shipment. Since wet ice is the most common means by which to refrigerate the samples, appropriate measures need to be taken to fully waterproof the contents from leakage. The field crew shall contact the laboratory each time samples are sent to identify the samples being sent and the transportation carrier along with the shipping identification number.

3 LABORATORY PROCEDURES/ PERFORMANCE STANDARDS

3.1 Analytical Methods

Chemical analyses will be performed by a laboratory that is certified by the State of Utah to analyze each Table 1 constituent. Methods and reporting limits will conform to Table 1 and will be performed in accordance with test procedures presented in USEPA *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, September 1986 and any subsequent revisions or additions.

Alternative methods that provide equivalent or better performance than those listed in EPA publication SW-846 and analytical methods for constituents not listed in EPA publication SW-846 may be implemented.

3.2 Deliverables (General and Supplemental QA/QC)

3.2.1 General Requirements

For general reporting of quantitative results for Subtitle D groundwater monitoring projects, the following reporting requirements apply:

- Methodology Summary - reporting of all the analytical test methods used in the analyses of the samples with a reference made for each to the method manual and the test method number to confirm compliance with Table 1.
- Summary of the analytical results, indicating appropriate unit, and reporting RL: and supervisor approval – concentration units must be consistently applied throughout report. Data cannot be method blank corrected. It must be appropriately flagged.
- Chain-of-Custody Form – As per Section 2.4.2.
- Field Data Sheets (see Appendix A) or equivalent form.

3.2.2 Supplemental QA/QC Reporting Requirements

- Laboratory Chronicles – must include date of sampling, sample receipt, preservation, preparation, analysis, and supervisor approval signature.

- Non-Conformance Summary for GC/MS Data Reports – must state if the following do not meet QA/QC requirements:

  GC/MS Tune Specifications
  GC/MS Tune Frequency
  Calibration Frequency
  Calibration Requirements – System Performance Check
  Compounds, Calibration Check Compounds
  Blank Contamination
  Surrogate Recoveries
  Sample Holding Times
  Minimum Detection Limits

3.2.3 Requirements for Organics: Volatiles

1. Quality Assurance (QA) Data Form – must include minimum detection limits, method blanks, field/trip blanks if specified in Sampling Plan, lab replicate. Quality Control (QC) samples may be other than project samples, but must be of same batch and similar matrix. A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form.

2. Surrogate Compound Recovery Summary – for samples and blanks – as per most recent version of applicable SW-846 method 8260.

3. Other requirements per Laboratory Quality Assurance Plan and regulatory requirements,

3.2.4 Laboratory Requirements for Metals

At a minimum, analytical results, method detection limits must be established and method blank results are mandatory.

3.2.5 Requirements for Inorganic - General Chemistry

Quality Assurance (QA) Data Form - must include minimum detection limits, method blanks, field/trip blanks as specified in Sampling Plan, lab replicate. Quality Control

(QC) samples may be other than project samples, but must be of same batch and similar matrix.

A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form. In addition, spiked sample results must be included.

3.3 Data Quality Objectives

3.3.1 Required Reporting Limits

Data reported must be such that the method used shall achieve the nominal reporting limits (RLs) listed in Table 1 - Background/Detection Monitoring Parameters

3.3.2 Precision

Precision refers to the reproducibility of method results when a second aliquot of the same sample undergoes duplicate analysis. The degree of agreement is expressed is the Relative Percent Difference (RPD). Precision requirements shall be as per applicable method and laboratory standards.

3.3.3 Accuracy

Accuracy refers to the agreement between the amount of a constituent measured by a test method and the amount actually known to be present. Accuracy is usually expressed as a percent Recovery (R). Accuracy shall be as per applicable method and laboratory standards.

4 SAMPLING FREQUENCY AND REPORTING REQUIREMENTS

4.1 Background

As per UAC R315-308-2 (4)(a), a minimum of eight (8) independent samples will be collected and analyzed to establish background for the constituents listed in Table 1 to establish background concentrations. Each monitor well in the site groundwater monitoring program will be defined as background or detection.

4.2 Detection Monitoring Events

After establishment of background values, sampling and analysis for both upgradient and downgradient detection monitoring wells will be conducted on a semi-annual basis (every six (6) months) for constituents listed in Table 1.

4.3 Groundwater Analysis Result Submittals

Two (2) bound copies of a report of all groundwater sampling and analysis results will be submitted to the Executive Secretary. The report will be submitted in standard laboratory format and on any applicable state agency reporting forms. Within a reasonable period of time after completing sampling, the owner/operator must determine whether there has been a statistically significant increase (SSI) over background at each monitoring well as per UAC R315-308-2 (4) (f) (v).

If there has been a statistically significant increase over background of any tested constituent at any monitoring well, a notice in writing to the UDEQ will be submitted within fourteen (14) days after the finding.

5 STATISTICAL METHODOLOGY - GROUND WATER DATA ANALYSIS

Statistical comparisons will be performed using Sanitas™, a commercial software program developed by Intelligent Decision Technologies, Inc. or another comparable computer program. Statistical analyses of groundwater data will be performed in accordance with UAC R315-308-2 (7). A statistical analysis plan has been prepared and included as Appendix D. Appendix D Statistical Analysis Plan has been prepared using generally accepted statistical analysis principals and practices (IDT, 2002). However, it is not possible to predict all of the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated.

5.1 Statistically Significant Constituents and Verification Resampling

Statistical analysis of constituents in Table 1 will commence within six (6) months after completion of eight (8) quarterly background events for a particular well. An initial Statistically Significant Increase (SSI) will be based on any compound detected in any downgradient monitor well at a concentration above the specific constituent's statistical limit. If an initial SSI of any constituent is indicated at any downgradient monitoring well, a notice will be made to the Department in the form of a statistical analysis report as referenced in Section 4.3 of this plan.

Verification resampling is an integral part of the presented statistical methodology. In the event of an initial SSI, verification resampling may be conducted and the results provided to the Executive Secretary in accordance with UAC R315-308-2 (10) (b).

As per UAC R315-308-2 (10) (c), the owner/operator may demonstrate within 90 days of the finding that the SSI is the result of a source other than the Municipal Solid Waste Landfill (MSWLF), such as error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Otherwise, the owner/operator must initiate an assessment monitoring program under UAC R315-308-2 (11).

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Table 1
List of Analytical Parameters
Wasatch Regional Landfill

Inorganic Constituents	CAS	Method[1]	RL[2] (mg/L)
Ammonia as Nitrogen	7664-41-7	350.1	1
Carbonate/Bicarbonate		310.1	10
Calcium		6010 or 6020	0.6
Chemical Oxygen Demand (COD)		410.2	10
Chloride		300.0	10
Iron	7439-89-6	6010 or 6020	0.1
Magnesium		6010 or 6020	0.2
Manganese	7439-96-5	6010 or 6020	0.015
Nitrate as Nitrogen		300.0 or 353.2	5
pH		150.1	N/A
Potassium		6010 or 6020	5
Sodium		6010 or 6020	5
Sulfate		300.0 or 375.4	10
Total Dissolved Solids (TDS)		160.1	10
Total Organic Carbon (TOC)		415.1	2
Heavy Metals	**CAS**	**Method[1]**	**RL[2] (mg/L)**
Antimony	7440-36-0	6010 or 6020 or 200.8	0.005
Arsenic	7440-38-2	7041 or 6020	~~0.05~~ 0.04
Barium	7440-39-3	6010 or 6020	0.02
Beryllium	7440-41-7	7091 or 6020	0.002
Cadmium	7440-43-9	6010 or 6020	0.001
Chromium		6010 or 6020	0.05
Cobalt	7440-48-4	6010 or 6020	0.07
Copper	7440-50-8	6010 or 6020	0.05
Lead		7421 or 6020 or 200.8	~~0.015~~ 0.01
Mercury	7439-97-6	6020 or 7470	~~0.002~~ 0.001
Nickel	7440-02-0	6010 or 6020	0.01
Selenium	7782-49-2	7740 or 6010 or 6020	0.02
Silver	7440-22-4	6010 or 6020	0.07
Thallium		7841 or 6020 or 200.8	~~0.4~~ 0.002

Table 1 (Continued)

Heavy Metals	CAS	Method[1]	RL[2] (mg/L)
Vanadium	7440-62-2	6010 or 7911	0.02
Zinc	7440-66-6	6010 or 6020	0.01

Volatile Organic Compounds	CAS	Method[1]	RL[2] (µg/L)
Acetone	67-64-1	8260B	10
Acrylonitrile	107-13-1	8260B	50
Benzene	71-43-2	8260B	4
Bromochloromethane	74-97-5	8260B	4
Bromodichloromethane	75-27-4	8260B	4
Bromoform (tribromomethane)	75-25-2	8260B	4
Carbon disulfide	75-15-0	8260B	4
Carbon tetrachloride	56-23-5	8260B	4
Chlorobenzene	108-90-7	8260B	4
Chloroethane (ethyl chloride)	75-00-3	8260B	8
Chloroform (trichloromethane)	67-66-3	8260B	4
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8260B	4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260B	0.2
1,2-Dibromoethane (ethylene dibromide, EDB)	106-93-4	8260B	0.05
o-Dichlorobenzene (1,2-dichlorobenzene)	95-50-1	8260B	4
p-Dichlorobenzene (1,4 dichlorobenzene)	106-46-7	8260B	4
trans-1,4-Dichloro-2-butene	110-57-6	8260B	4
1,1-Dichloroethane (ethylidene chloride)	75-34-3	8260B	4
1,2-Dichloroethane (ethylene dichloride)	107-06-2	8260B	4
1,1-Dichloroethylene (1,1-dichloroethene)	75-35-4	8260B	4
cis-1,2-Dichloroethylene (1,1-dichloroethene)	156-59-2	8260B	4
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	156-60-5	8260B	4
1,2-Dichloropropane (propylene dichloride)	78-87-5	8260B	4
cis-1,3-dichloropropene	10061-01-5	8260B	2
trans-1,3-dichloropropene	10061-02-6	8260B	2

revised

Table 1` (Continued)

Volatile Organic Compounds	CAS	Method[1]	RL[2](μg/L)
Ethylbenzene	100-41-4	8260B	~~5~~ 4
2-Hexanone (methyl butyl ketone)	591-78-6	8260B	~~10~~ 5
Methyl bromide (bromomethane)	74-83-9	8260B	~~10~~ 5
Methyl chloride (chloromethane)	74-87-3	8260B	2
Methylene bromide (dibromomethane)	74-95-3	8260B	~~5~~ 4
Methylene chloride (dichloromethane)	75-09-2	8260B	~~5~~ 4
Methyl ethyl ketone (MEK, 2-butanone)	78-93-3	8260B	~~10~~ 5
Methyl iodide (iodomethane)	74-88-4	8260B	~~5~~ 4
4-Methyl-2-pentanone (methyl isobutyl ketone)	108-10-1	8260B	~~10~~ 5
Styrene	100-42-5	8260B	~~5~~ 4
1,1,1,2-Tetrachloroethane	630-20-6	8260B	~~5~~ 4
1,1,2,2-Tetrachloroethane	79-34-5	8260B	~~5~~ 4
Tetrachloroethylene (tetrachloroethene)	127-18-4	8260B	~~5~~ 4
Toluene	108-88-3	8260B	~~5~~ 4
1,1,1-Trichloroethane (methylchloroform)	71-55-6	8260B	~~5~~ 4
1,1,2-Trichloroethane	79-00-5	8260B	~~5~~ 4
Trichloroethylene (trichloroethene)	79-01-6	8260B	~~5~~ 4
Trichlorofluoromethane (CFC-11)	75-69-4	8260B	~~5~~ 4
1,2,3-Trichloropropane	96-18-4	8260B	~~5~~ 4
Vinyl acetate	108-05-4	8260B	~~10~~ 5
Vinyl chloride	75-01-4	8260B	2
Xylenes (total)	1330-20-7	8260B	~~5~~ 4

1. Equivalent or better methods may be submitted as appropriate
2. Reporting Limits

For the compounds DBCP and EDB, any detectable amount between the RL and MCL will be estimated and flagged with an appropriate symbol.

APPENDIX A

FIELD DATA SHEET

Wasatch Regional Landfill	GROUNDWATER SAMPLING FIELD DATA SHEET Well Number:____________________ Sample I.D.: ________________ (if different from well
Project: __________________________ Personnel:_________________________	Date: _______________ Weather: __________________ Air Temp: ______

WELL DATA:

Casing Diameter: ______ (in) ☐ PVC ☐ Other: _

DEPTH TO: Static Water Level (WL): ________ (ft) Total Depth (TD): _______ (ft)

DATUM: ☐ Top of Well Casing ☐ Top of Protective Casing

CONDITION: Is well clearly labeled? ☐ Yes ☐ No

Is prot. casing in good cond.? (not bent or corroded) ☐ Yes ☐ No

Is concrete pad intact? (not cracked or frost heaved) ☐ Yes ☐ No

Is padlock functional? ☐ Yes ☐No Is inner casing intact? ☐ Yes ☐ No

Is inner casing properly capped and vented? ☐ Yes ☐ No

Comments: ____

PURGE DATA: One Casing Volume = (d/24)2 (23.5)(TD-WL)

METHOD: ☐ Bladder Pump ☐ Bailer ☐ Other: ____________ Low-Flow Purging Used? ☐Yes ☐ No

MATERIALS: Type of Pump: _

Tubing: ☐Teflon® ☐ Polyethylene ☐ Polypropylene ☐ Other: ____________

PURGING EQUIPMENT: ☐ Dedicated ☐ Prepared Off-Site ☐ Field-Cleaned

PROCEDURES: Pump & Tubing Vol.: _________(ml) Pumping Rate: _______ (ml/min)

CALIBRATION: pH Meter Model: _______________ Meter S/N: ________________ Time: ________

Cond. Meter Model: ________________ Meter S/N: ________________ Time: ________

Disposition of Purge Water: ____

TIME SERIES DATA:

Time:							
Cum. Volume(ml)							
Temperature (®C)							
pH (s.u.):							
Spec. Cond. (µmhos/cm):							
Turbidity (NTU):							
Other							

SAMPLING DATA:

Sample Collection Time: ____________________

Water Level at Time of Sample: ____________________

METHOD: ☐ Bladder Pump ☐ Bailer ☐ Other: ____________

SAMPLING EQUIPMENT: ☐ Dedicated ☐ Prepared Off-Site ☐Field-Cleaned

APPEARANCE: ☐ Clear Turbid (NTU): _____________Color: _____________ ☐ Contains Immiscible Liquid

FIELD DETERMINATIONS: Temp. (°C):__________pH (s.u.):____________Spec. Cond. (µmhos/cm): ___________

General Remarks: ____

____

____

I certify that this sample was collected and handled in accordance with applicable regulatory and project protocols.

Signature:_______________________________________ Date:______________________________

RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	Container$_a$	Preservative	Holding Times	Reference
Physical Properties					
Specific Cond. (Field)	100	P,G	None	Det. on Site	1
Specific Cond. (Lab)	100	P,G	Cool, 4 °C	28 Days	1
pH (Field)	50	P,G	None	Det. on Site	1,2
pH (Lab)	50	P,G	None	24 Hrs	1,2
Temperature	1000	P,G	None	Det. On Site	1
Turbidity	100	P,G	None	Det. On Site	1

Measurement	Volume (mL)	Container$_a$	Preservative	Holding Times	Reference
Inorganics, Non-Metallics					
Carbonate/Bicarbonate	200	P,G	Cool, 4 °C	14 days	1
Chloride	200	P,G	None	28 Days	1,2
Nitrate plus Nitrite	200	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	1,2
COD	50	P,G	H_2SO_4 to pH <2	28 days	1
Sulfate	100	P,G	Cool, 4 °C	28 days	1,2
Ammonia as Nitrogen	1000	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	2,3
Total Dissolved Solids (TDS)	500	P,G	Cool, 4 °C	7 days	2,3
Total Organic Carbon (TOC)	250	P,G	Cool, 4 °C HCL or H_2SO_4 to pH <2	28 days	2,3

Appendix B
revised

RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	Container[a]	Preservative	Holding Times	Reference
Metals (except mercury)					
Total	500	P,G	HNO_3 to pH <2	6 Mos	1,2
Dissolved	500	P,G	Filt. + HNO_3 to pH <2	6 Mos	1,2
Mercury – Total	500	P,G	HNO_3 to pH <2	28 days	1,2
Mercury – Dissolved	300	P,G	Filt. + HNO_3 to pH <2	28 days	1,2

Measurement	Volume (mL)	Container[a]	Preservative	Holding Times	Reference
Organics					
Volatile Organics by GC/MS	100 (2 vials @ 40ml)	G, Teflon septum cap	Cool, 4 °C HCL to pH <2	14 days	2,3
Herbicides	1000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3
Pesticides and PCB's	1000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3
Semi-Volatiles Acid and Base/Neutral Compounds	2000	Glass Only	Cool, 4 °C	7 days [b] 40 days [c]	2,3

NOTES:

a Plastic (P) or Glass (G). For metals, polyethylene with an all polypropylene cap is preferred.

b Maximum holding time from sampling to extraction.

c Maximum holding time from extraction to analysis.

REFERENCES:

1 Methods for Chemical Analysis of Water and Wastes, March, 1983, USEPA, 600/4-79-020 and additions thereto.

2 Test Methods for Evaluating Solid Waste, Physical/Chemical Method, November, 1986, Third Edition, USEPA, SW-846 and additions thereto.

3 "Guidelines Establishing Test Procedures for the Analysis of Pollutant Under the Clean Water Act", Environmental Protection Agency, Code of Federal Regulations (CFR), Title 40, Part 136.

APPENDIX ~~D~~ C

SAMPLE CHAIN-OF-CUSTODY

Chain of Custody Record

SEVERN TRENT **STL**

Severn Trent Laboratories, Inc.

STL-4124 (0901)

Client	Project Manager	Date	Chain of Custody Number 168232
Address	Telephone Number (Area Code)/Fax Number	Lab Number	Page ____ of ____

City	State	Zip Code	Site Contact	Lab Contact
Project Name and Location (State)			Carrier/Waybill Number	
Contract/Purchase Order/Quote No.				

Analysis (Attach list if more space is needed)

Special Instructions/ Conditions of Receipt

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc/ NaOH		Analysis												Special Instructions/ Conditions of Receipt

SAMPLE

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months

(A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required
☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other ______________

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By			1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: ...TE - Returned to Client with Report; CANARY - Stays with the Sample; PINK - Field Copy

APPENDIX D

STATISTICAL ANALYSIS PLAN

CONTENTS

1 INTRODUCTION

This document provides a statistical methodology for groundwater monitoring at the City of Wasatch Regional Landfill. A tiered evaluation approach has been developed for detection monitoring wells. Intrawell comparisons of metals and inorganic indicator parameters will be conducted using Shewhart-CUSUM control charts. Non-parametric prediction limits combined with Sen's Slope/MannKendall trend analysis will be applied to those parameters with greater than 50 percent non-detections (25 percent under ASTM standards) in the background data set. Statistical limits for volatile organic compounds in detection monitoring wells will be based on reporting limits (RLs). Assessment monitoring constituents will be statistically evaluated using detection monitoring statisticis and 95 percent confidence interval analysis. Details of each method are provided in the following sections. Statistical comparisons will be performed using Sanitas™, a commercial software program developed by Intelligent Decision Technologies, Inc. or another comparable computer program.

This document has been prepared using generally accepted statistical analysis principals and practices. However, it is not possible to predict all of the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated.

2 DETECTION MONITORING STATISTICAL ANALYSES

2.1 Metals and Inorganic Indicator Constituents

2.1.1 Shewhart-CUSUM Control Charts

Metals and inorganic indicator constituents will be statistically evaluated using combined Shewhart-CUSUM Control Charts. This procedure assumes that the data are independent and normally distributed with a fixed mean and constant variance. The most important assumption is independence, therefore wells should be sampled no more frequently than quarterly (Gibbons, 1994). The assumption of normality is less of a concern and natural log or ladder of powers transformations are adequate for most applications. The analysis is only applied to constituents that have greater than 50 percent detections (25 percent under ASTM standards) in the background data. For those metals and inorganic indicator constituents with fewer than 50 percent detections in the background data set, a non-parametric prediction limit/Sen's Slope/Mann Kendall trend analysis will be used.

Shewhart-CUSUM control charts allow detection of both major and gradual releases from the facility independent of spatial variation. This procedure is specifically recommended in the USEPA document *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (April 1989).

2.1.2 Procedure

Control charts are a form of time-series graph, on which a parametric statistical representation of concentrations of a given constituent are plotted at intervals over time. The statistics are computed and plotted together with an upper and/or lower control limit on a chart where the x-axis represents time.

The Procedure for conducting the intrawell analysis using combined Shewhart-CUSUM Control Charts is provided below and a flow chart illustrating the decision making process is provided as Figure D-1:

Three parameters are selected prior to plotting:

h - The control limit to which the cumulative sum (CUSUM) values are compared. The EPA recommended value for **h** is 5 units of standard deviation.

k - A reference value that establishes the upper limit for the acceptable displacement of the standardized mean. The EPA recommended value for k is 1.

SCL - The upper Shewhart control limit to which the standardized mean will be compared. The EPA recommended value for **SCL** is 4.5.

For each time period, T_i, take n_i independent samples (n_i may be one), and calculate the mean, $\bar{x}_i$. Compute the standardized mean Z_i of the measured concentrations where only a single new measurement is obtained for each constituent at each event as :

$$Z_i = \left(X_i - \overline{X}\right)\sqrt{n_i} / S$$

Where:

x_i = value obtained for a constituent during monitoring event i.

s = The standard deviation obtained from prior monitoring data from the same well.

When applicable, for each time period, T_i, compute the cumulative sum, S_i, as:

$$S_i = \max\{0, (Z_i - k) + S_{i-1}\}$$

Where max {A,B} is the maximum of A and B, and $S_o = 0$.

Plot Z_i and S_i against Ti on the control chart. The results may be plotted in standardized units or converted to the concentration units of the constituents being evaluated. An "out-of-control" situation (potential contamination) occurs whenever $Z_i \geq$ SCL or $S_i \geq h$. Two different types of situation are controlled by the limits. Too large a standardized mean will occur if there is a rapid increase in concentration in the well. Too large a cumulative sum may also occur for a more gradual trend. A verified statistically significant change (SSC) will occur if both the initial result *and* a verification sample result consecutively exceed one of the above mentioned statistical limits. Upgradient wells will be monitored for informational purposes only and will not be part of the verification resampling program.

2.1.2.1 Verification Resamples

The Shewhart and CUSUM portions of the control chart are affected differently by initial statistically significant changes from background (SSCs). The Shewhart portion of the control chart compares each individual new measurement to the control limit, therefore the next monitoring event constitutes an independent verification of the original result. However, the CUSUM procedure incorporates all historical values in the computation, therefore, the effect of the apparent SSC will be present in both the initial and verification sample. Hence, the statistical test will be invalid unless the verification sample value replaces the initial SSC value. Therefore, initial SSC values will be replaced by verification resample results in order to confirm a SSC (Gibbons, 1994).

2.1.2.2 Updating Control Charts

As monitoring continues, the background mean and variance will be updated periodically to incorporate new data. At a minimum of every two years all new data that are in control will be pooled with the initial eight background samples and the mean and variance will be recomputed and used in constructing future control charts. ~~TCEQ~~ UDEQ (Utah Department of Environmental Quality) approval will be obtained prior to updating the background data pool.

2.1.2.3 Censored Data

If less than 15 percent of the background observations are nondetects, these will be replaced with one half of the laboratory reporting limit prior to running the analysis (U.S. EPA, April 1989).

If more than 15 percent but less than 50 percent of the background data are less than the detection limit, the data's sample mean and sample standard deviation are adjusted according to the method of Cohen or Aitchison.

If more than 50 percent of the background data are less than the detection limit, a nonparametric prediction limit will be computed.

2.1.3 Non-Parametric Prediction Limits and Sen's Slope/Mann Kendall Trend Analysis

For those metals and inorganic indicator constituents with fewer than 50-percent detections within the background pool, a combined non-parametric upper prediction limit/Sen's Slope/MannKendall trend ananlysis will be applied. Parameters will be initially tested using the non-parametric prediction limit analysis. Constituents exceeding the non-parametric prediction limit will then be tested using the Sen's Slope/Mann Kendall trend analysis. An initial statistical exceedence will be indicated if the measured concentration exceeds both the non-parametric prediction limit and exhibitis a significant upward trend. The combined methods provide a non-parametric control chart equivalent to allow detection of both major and gradual releases from the facility independent of spatial variation.

2.1.3.1 Non-Parametric Prediction Limit Analysis

An upper prediction limit is a statistical limit calculated to include one or more observations from the same population with a specified confidence. In groundwater monitoring, an upper prediction limit approach may be used to make comparisons between background and compliance well data. The limit is constructed to contain all **k** observations with stated confidence. Any observation exceeding the upper prediction limit provides statistically significant evidence that the observation is not representative of the background group. The number of observations, **k**, to be compared to the limit must be specified in advance. A flow chart illustrating the decision making process during the analysis is provided as Figure D-2.

The highest value from the background data is used to set the upper prediction limit. In the case of a two-tailed test, the lowest value from the background data is used to set the lower prediction limit. Under EPA Standards, the false positive rate is based upon the formula:

$$1-(n/(n+k))$$

Where:

n = The background sample size, and

k = The number of future values being compared to the limit.

2.1.3.2 Sen's Slope/Mann Kendall Trend Analysis

The Sen's Slope/Mann Kendall trend analysis procedure determines the significance of an apparent trend and evaluates the magnitude (slope) of that trend (IDT, 2002). The Mann Kendall test for temporal trend is a non-parametric procedure designed to test the null hypothesis, H_0:

H_0: No significant trend of a constituent exists over time.

And the alternative hypothesis, H_A:

H_A: A significant upward trend of a constituent concentration exists over time.

Wells for which less than 41 data points are available, the exact test is applied. For 41 or more data points, the Normal Approximation test is used.

The Sen's Slope estimator portion of the combined method provides an estimate of the true slope. The method is a non-parametric procedure not greatly affected by gross data errors or outliers, and can be computed when data are missing.

2.2 Statistical Evaluation of Volatile Organic Compounds

Volatile organic compounds (VOCs) will be routinely monitored during the detection monitoring program. The statistical limit for VOCs detected in wells under detection monitoring will be set equal to the laboratory reporting limit (RL). RLs are provided in Table 1 of the facility's Groundwater Sampling and Analysis Plan (GWSAP). As with the prediction limit statistical method, VOC detections will not be considered statistically significant unless confirmed by verification resampling. Verification resampling procedures are provided in Section 2.3 and in the GWSAP.

2.3 Verification Resampling

Results for constituents that exceed statistical limits will not be considered statistically significant unless they are confirmed through verification resampling.

If a statistically significant change (SSC) from background of any tested constituent at any monitor well has occurred (i.e. is confirmed) and there is reasonable cause that a source other than the landfill exists, then a report will be submitted documenting the source as per Section 5.1 of the GWSAP and UAC R315-308-2 (10)(c). Otherwise, assessment monitoring will be implemented in accordance with Section 5.1 of the GWSAP and UDEQ regulations.

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3 ASSESSMENT MONITORING STATISTICAL ANALYSIS

For assessment wells, constituents exceeding detection monitoring statistical limits and that have a groundwater protection standard (GWPS) established by the USEPA or the UDEQ, and/or any VOC detections will be statistically compared to GWPS using one-sided 95-percent lower confidence limits (LCL). Evaluations are conducted per Gibbons and Coleman (2001). The method constructs a normal confidence interval on the mean concentration of a constituent incorporating, at a minimum, the four most recent semi-annual measurements. A separate interval is constructed for each constituent of interest in each well of interest. A confidence interval is generally used when downgradient samples are being compared to a Groundwater Protection Standard (GWPS). A flow chart depicting the decision making process during the analysis is provided as Figure E-3.

The lower 95-percent confidence limit on the mean will be compared to a GWPS to decide initially whether the mean concentration of a constituent of interest has exceeded a GWPS. If the lower 95-percent confidence limit on the mean exceeds the GWPS then there is statistically significant evidence that the mean concentration of that constituent exceeds the GWPS. Upper 95-percent confidence limit analyses may be applied to constituents in which it's 95 percent LCL has exceeded a GWPS. If the upper 95-percent confidence limit on the mean occurs lower that the GWPS then there is statistically significant evidence that the mean concentration of that constituent has returned to less than the GWPS.

3.1 Assumptions

The sample data used to construct the limits must be normally or transformed-normally distributed. In the case of a transformed-normal distribution, the confidence limit must be constructed on the transformed sample concentration values. In addition to the limit construction, the comparison must be made to the transformed GWPS value. When none of the transformed models can be justified, a nonparametric version of each limit may be utilized.

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3.2 Distribution

The distribution of the data is evaluated by applying the Shapiro-Wilk or Shapiro-Francia test for normality to the raw data or, when applicable, to the Ladder of Powers (Helsel & Hirsch, 1992) transformed data. The null hypothesis, $\mathbf{H_O}$, to be tested is:

> $\mathbf{H_O}$: The population has a normal (or transformed-normal) distribution.

The alternative hypothesis, $\mathbf{H_A}$, is:

> $\mathbf{H_A}$: The population does not have a normal (or transformed-normal) distribution.

3.3 Censored Data

If less than 15 percent of the observations are non-dectects, these will be replaced with one half the method detection limit prior to running the normality test and constructing the confidence limit.

If more than 15 percent, but less than 50 percent, of the data are less than the detection limit, the data's sample mean and standard deviation are adjusted according to the method of Cohen or Aitchison (U.S. EPA, April 1989). This adjustment is made prior to construction of the confidence limit.

If more than 50 percent of the data are less than the detection limit, these values are replaced with one half the method detection limit and a nonparametric confidence limit is constructed.

3.4 Parametric Confidence Limit Procedures

A minimum of four sample values is required for the construction of the parametric confidence limit. The mean, **X**, and standard deviation, **S**, of the sample concentration values are calculated separately for each compliance well. For each well, the confidence limit is calculated as:

$$\overline{X} \pm t_{(1-\alpha,\, n-1)} \frac{S}{\sqrt{n}}$$

Where:

S = The compliance point's standard deviation;

n = The number of observations for the compliance point; and

$t_{(1-\alpha,,n-1)}$ is obtained from the Student's t-Distribution (appendix B; U.S. EPA, April 1989) with (n-1) degrees of freedom.

The use of the 95th percentile of the t-Distribution is consistent with the 5 percent α - level of individual well comparisons. If the lower limit is above the compliance limit, there is statistically significant evidence that the constituent exceeds a GWPS.

3.5 Nonparametric Confidence Limit Procedure

The nonparametric confidence limit procedure requires at least seven observations in order to obtain a one-sided significance level of 1 percent. The observations are ordered from smallest to largest and ranks are assigned separately within each well. Average ranks are assigned to tied values. The critical values of the order statistics are determined as follows.

If the minimum seven observations are used, the critical values are the first and seventh values. Otherwise, the smallest integer, **M**, is found such that the cumulative binomial distribution with parameters **n** (sample size) and probability of success, p=0.5, is at least 0.99.

The exact confidence coefficient for sample sizes from 4 to 11 are given by the EPA (Table 6-3; U.S. EPA, April 1989). For larger samples, take as an approximation the nearest integer value to:

$$\mathbf{M} = \frac{n}{2} + 1 + \mathbf{Z}_{(1-\alpha)} \sqrt{\frac{n}{4}}$$

Where:

$\mathbf{Z}_{(1-\alpha)}$ = The 1-α percentile from the normal distribution found in Table 4 (appendix B; U.S. EPA, April 1989); and

n = The number of observations in the sample.

Once **M** has been determined, **(n+1-M)** is computed and the confidence limits are taken as the order statistics, **X(M)** and **X(n+1-M)**. These confidence limits are compared to the GWPS as discussed in Section 3.

4 REFERENCES

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International Ground Water Modeling Center, 1995. Ground Water Statistics and Regulations, Colorado School of Mines, Golden, Colorado.

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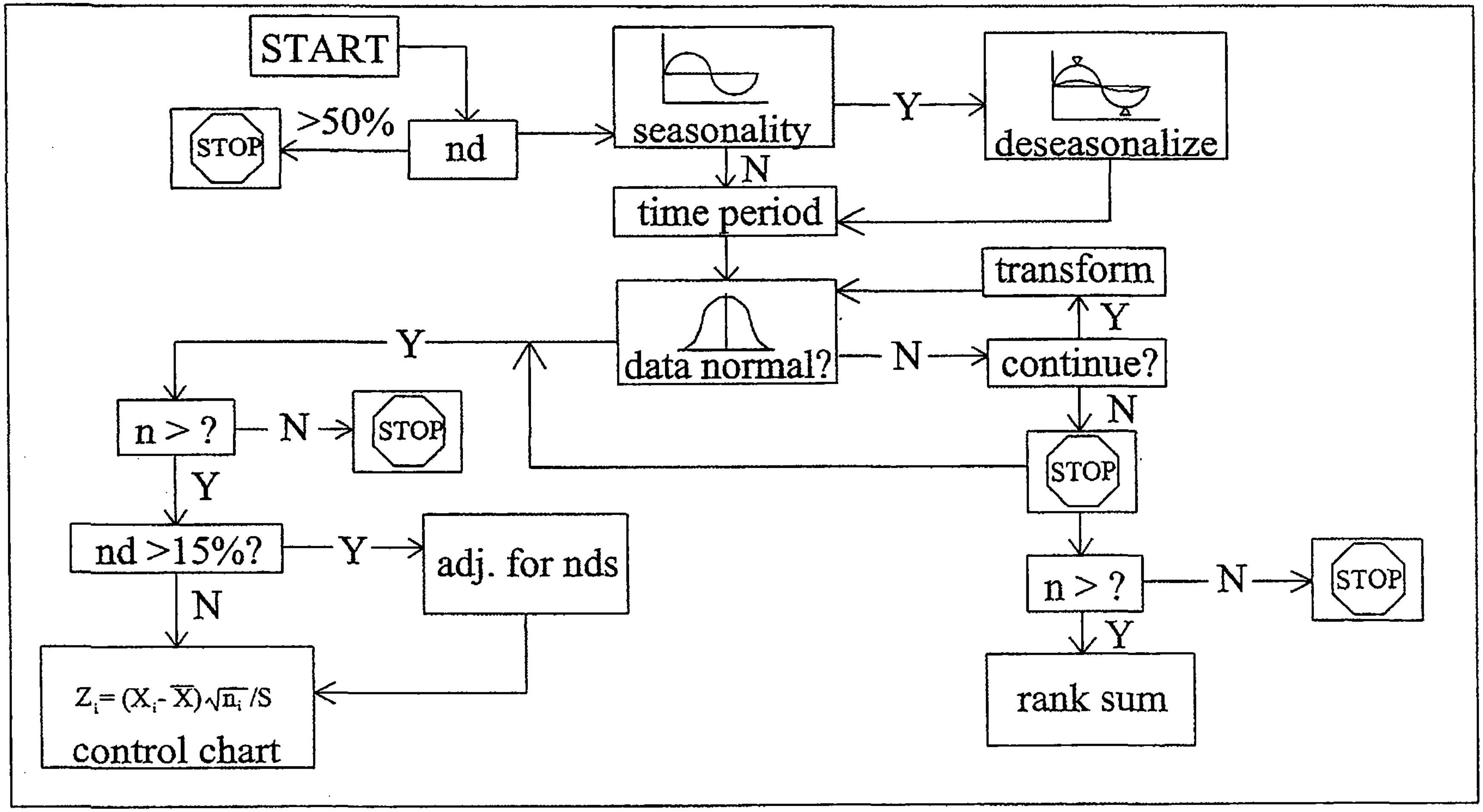
U.S. Environmental Protection Agency, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance, EPA/530/SW-89/026.

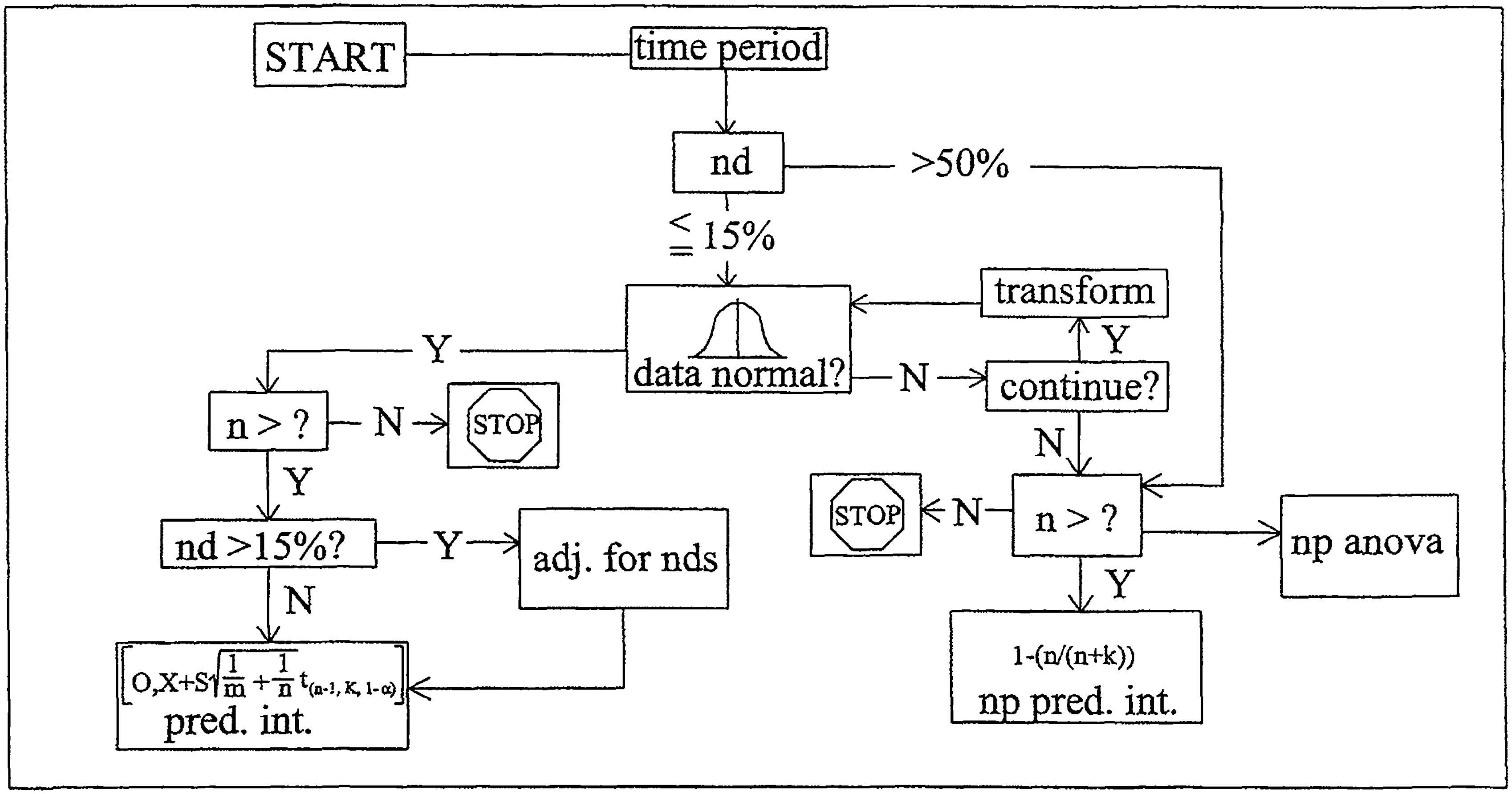
USEPA. 1992. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance (Draft).

FIGURE E-1
CONTROL CHART FLOWCHART



Source: Sanitas™ version 7.5

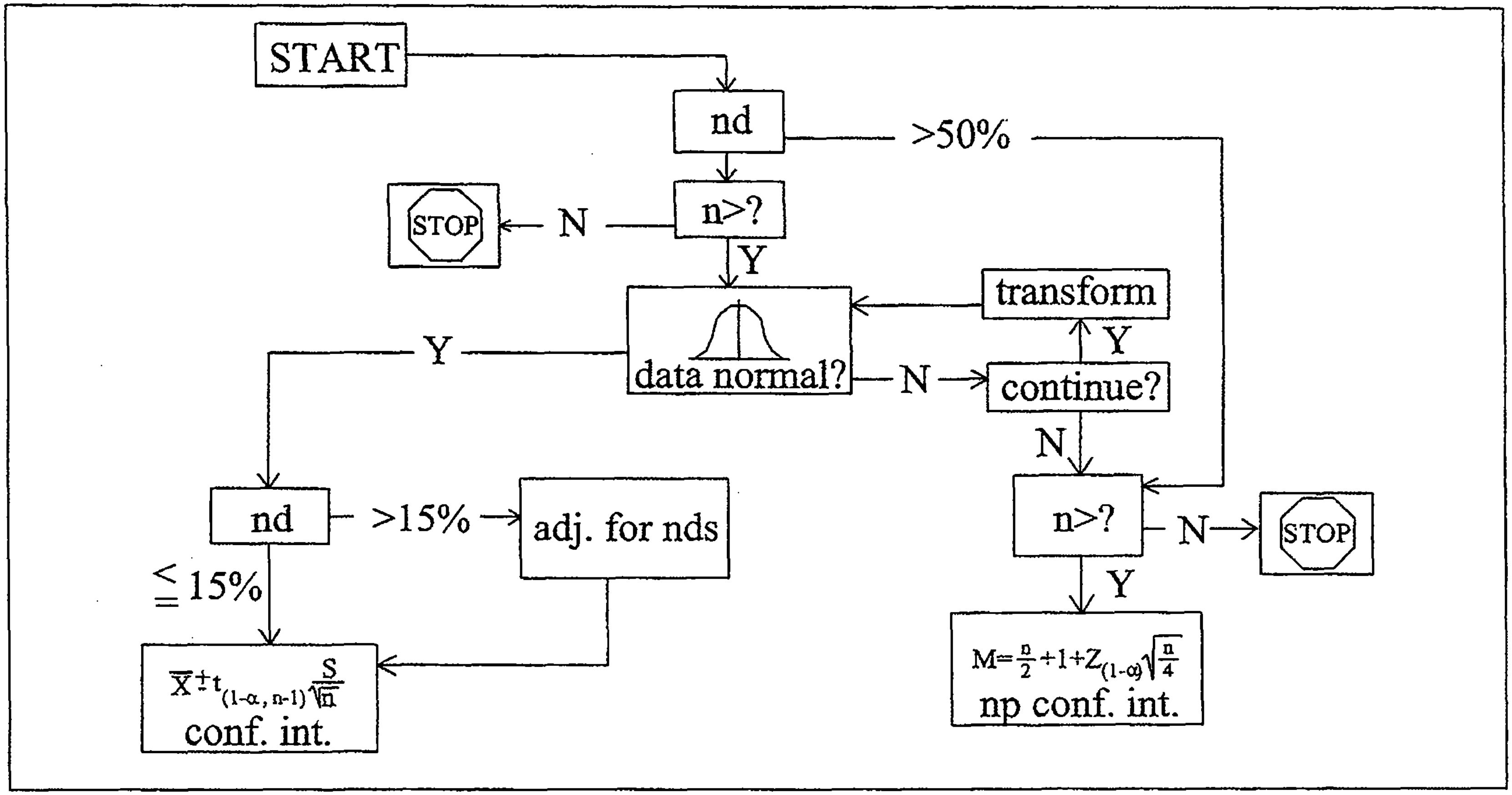
FIGURE E-2
PREDICTION LIMIT FLOWCHART



Source: Sanitas™ version 7.5

FIGURE E-3

95% CONFIDENCE INTERVAL FLOWCHART



Source: Sanitas™ version 8.0

APPENDIX C

CALIBRATION DATA SHEET

Calibration Data Sheet

Project:____________________________________
Calibrated By:________________________________
Date:____________________ **Time:**____________

Calibration Solution Temperature:________ C

pH Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known pH __________________

Conductivity Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known Conductance __________________

Turbidity Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known Turbidity __________________

Date:____________________ **Time:**____________

Calibration Solution Temperature:________ C

pH Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known pH __________________

Conductivity Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known Conductance __________________

Turbidity Meter

Model __________________
Serial Number __________________
Calibration Solution __________________
Instrument Reading __________________
Known Turbidity __________________

Comments:____
____

Applied Geotechnical Engineering Consultants, P.C.

RECEIVED
AUG 0 9 2005
H A & L

August 8, 2005

Hansen Allen & Luce, Inc.
6771 South 900 East
Midvale, UT 84047

Attention: Kent Staheli
FAX: 566-5581

Subject: Summary of Drilling and Completion of Borings
Wasatch Regional Solid Waste Landfill
Tooele County, Utah
AGEC Project No. 1040644

Gentlemen:

Applied Geotechnical Engineering Consultants, P.C. (AGEC) was requested to summarize the drilling and completion of borings for the Wasatch Regional Solid Waste Landfill to be located in Tooele County, Utah.

PREVIOUS STUDIES

AGEC previously conducted a geotechnical investigation (permit modification) for the Wasatch Regional Solid Waste Landfill and presented our findings and recommendations in a report dated June 15, 2005 under AGEC Project No. 1040644.

SUBSURFACE EXPLORATION

The subsurface conditions at the site were investigated by drilling five borings at the approximate locations indicated on Figure 1. Three of the borings were advanced to groundwater and PVC pipe was installed. The drilling extended down to a maximum depth of approximately 173 feet. Drilling was initially started using 8-inch diameter hollow-stem auger powered by an all-terrain drill rig. For the deeper exploration, and in more difficult drilling conditions, rotary methods using a 3½ inch diameter tricone bit was used with air as the circulation fluid.

The following table summarizes the approximate ground surface and subsurface water elevations, the boring depths and the depth of PVC pipe.

Boring Location	Approximate Ground Surface Elevation (ft)	Approximate Subsurface Water Elevation (ft)	Bottom Elevation of Boring (ft)	Bottom Elevation of PVC Pipe (ft)
B-1	4386.3	4232	4213	4223
B-2	4349.7	None to 4269	4269	Not Applicable
B-3	4249.1	4227	4213½	4214
B-4	4301.8	4225	4222	4222
B-5	4248.2	4226	4212½	4214

The approximate ground surface elevation was provided by representatives of Hansen Allen & Luce, Inc.

BORING COMPLETION

The PVC and backfill materials were installed through the 8-inch diameter hollow-stem augers used to advance the borings in Borings B-1, B-3, B-4 and B-5. No PVC pipe was installed in Boring B-2 due to the lack of water at the depth investigated. Slotted PVC pipe, 1½ inches in diameter, was installed in Boring B-4.

Slotted, 1½ inch diameter PVC pipe was installed in Boring B-4. The PVC pipe was slotted by hand sawing slots at random locations along the length of PVC pipe. The PVC pipe extends the full depth of the boring. The boring was backfilled with cuttings obtained from the boring advancement.

Generally, the boring completion construction was the same for Borings B-1, B-3 and B-5. A schematic showing the general details of the boring completion is presented on Figure 2. The PVC pipe installed consists of 2-inch diameter, Schedule 40 PVC pipe and a conical endcap (plug) was placed at the base. A 5-foot length of solid PVC pipe extends above the endcap (sump portion). Approximately 15 to 20 feet of machine slotted PVC pipe extends above the sump portions. The slots measure approximately 0.01 inches in width. The slotted PVC pipe portion was installed with the measured subsurface water level centered in the screened portion of the well. Solid PVC pipe extends from the screened portion of the well to the ground surface.

The PVC elements were seated on 10X20 silica sand. The borings were backfilled with silica sand from the bottom of the hole to approximately ½ to 8 feet above the screened portion of the PVC pipe. Bentonite chips with a maximum particle size of approximately ⅜ inch was used to backfill the remainder of the hole up to the ground surface.

	Boring Completion Depths		
Item	B-1	B-3	B-5
Depth of Boring, ft.	173	35½	35½
Solid PVC Pipe, ft.	0-138	0-14	0-14
Screened PVC Pipe, ft.	138-158	14-29	14-29
Solid PVC Pipe, ft.	158-163	29-34	29-34
Bentonite Backfill, ft.	0-130 and 163-173	0-11	0-13½
Silica Sand Backfill, ft.	130-163	11-34	13½-34

The borings were completed with the construction indicated above to be used as monitoring wells or piezometers as needed.

Each PVC pipe was secured with a locking PVC cap. A steel protective casing was placed above the portion of the PVC pipe which extends above the existing ground surface (approximately 2 to 3 feet). The protective cover was secured in place with a concrete pad which slopes away from the casing in all directions. A padlock secures each of the protective casings.

If you have any questions or if we can be of further service, please call.

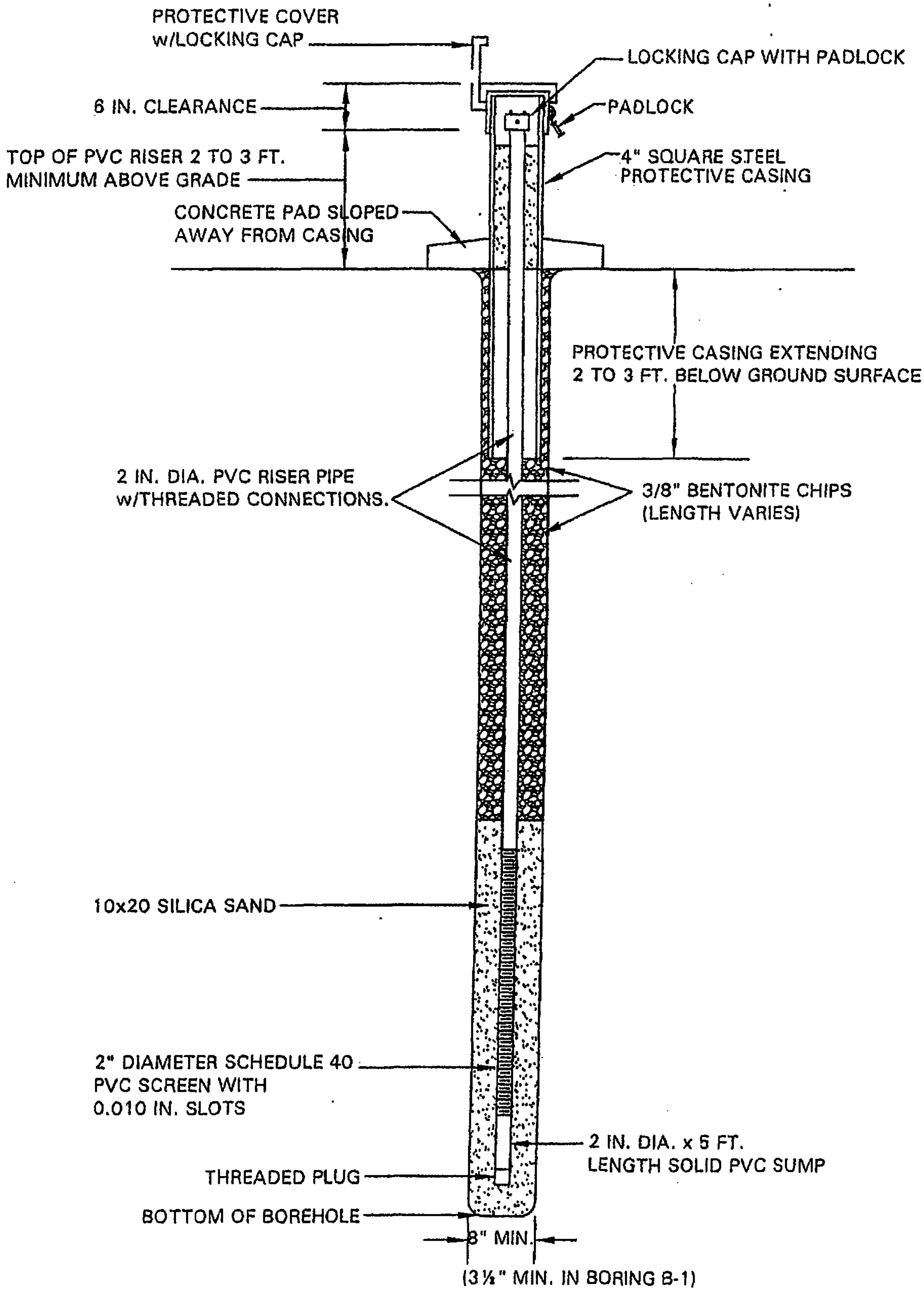
Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, P.C.

Christopher J. Beckman

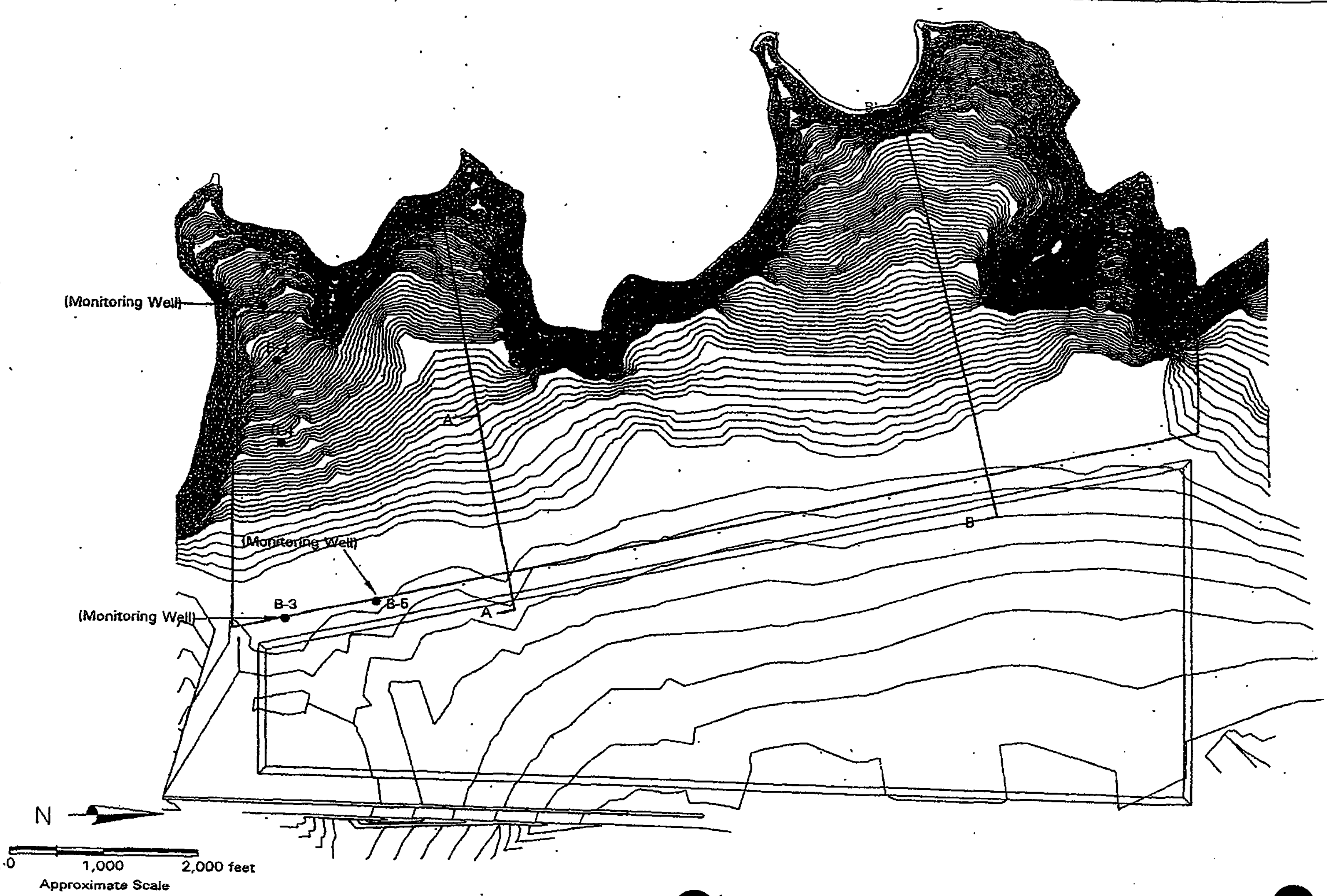
Christopher J. Beckman, P.E.

Reviewed by JEN, P.E.
CJB/dc
Enclosures



Note: Bentonite chips was placed below the PVC pipe in Boring B-1.

1040644 | AGEC | Typical Boring Completion | Figure 2



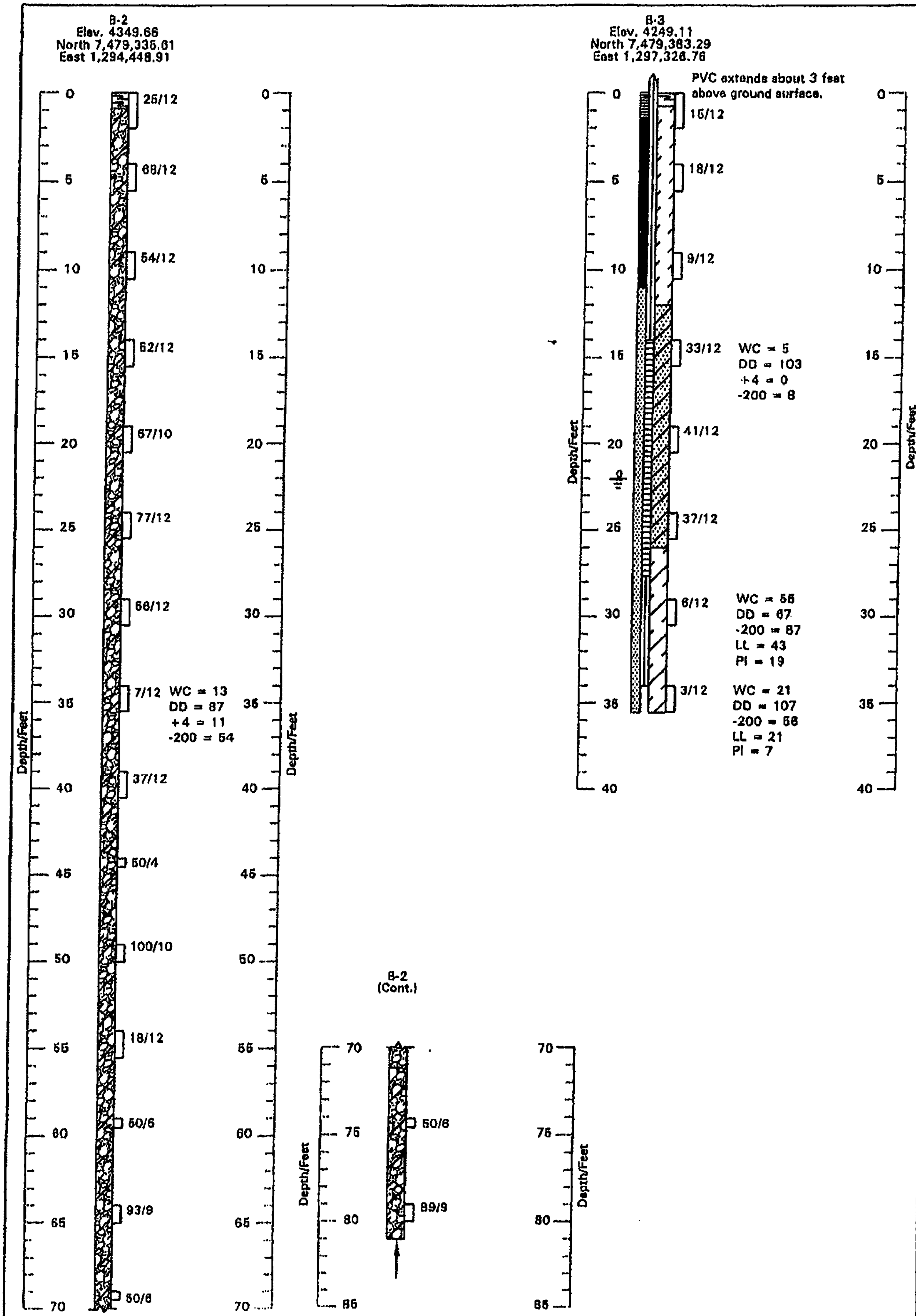
10406- | AGES | Locations of Exploratory Borings

HANSEN ALLEN & LUCE inc.
CONSULTING ENGINEERS

SALT LAKE AREA OFFICE
6771 SOUTH 900 EAST
MIDVALE, UTAH 84047
Tel: (801) 566-5599
Fax: (801) 566-5581
Web Site: hansenallenluce.com

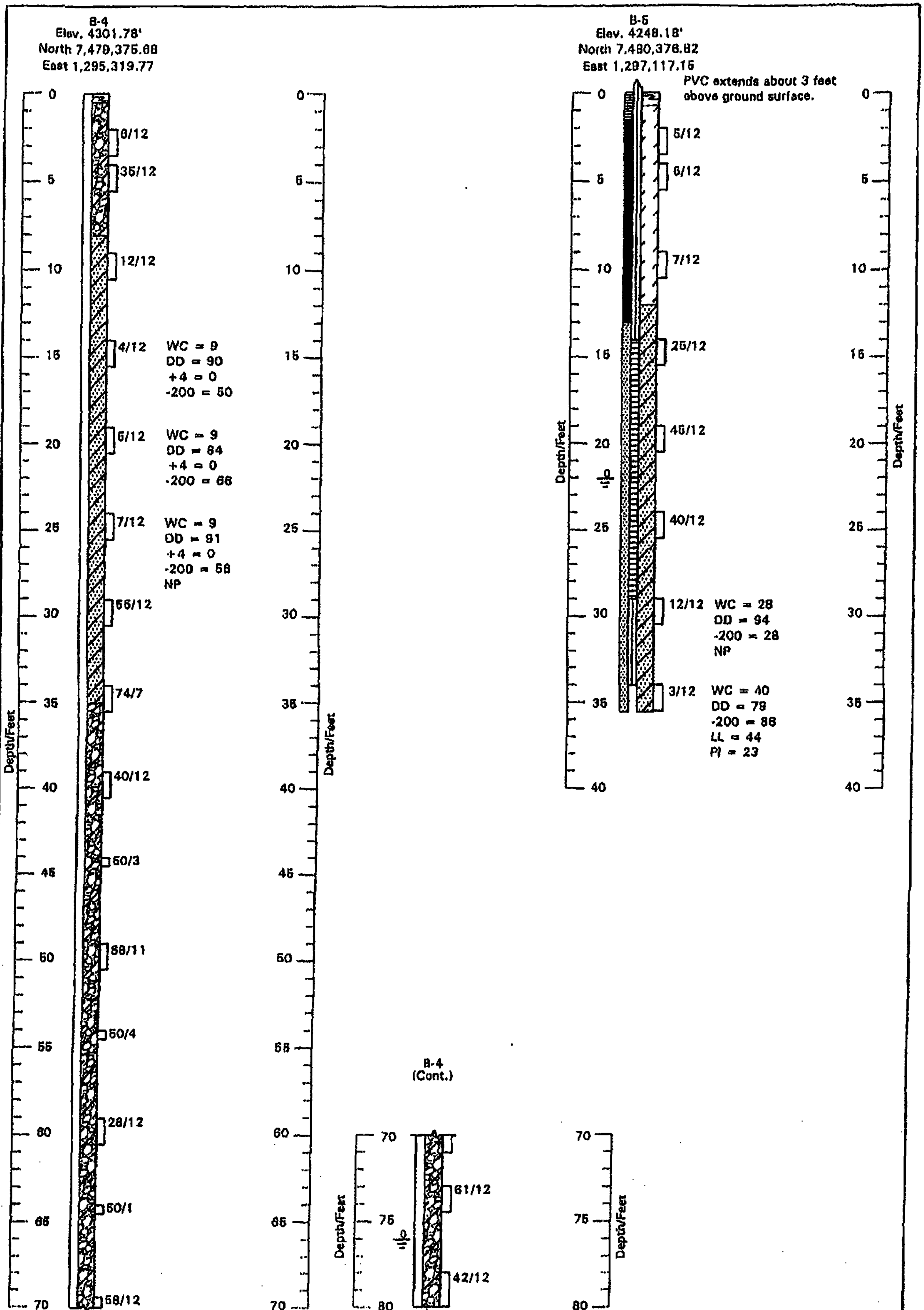
FACSIMILE TRANSMISSION

Page:	1 of 4
Date:	4-6-5
To:	Darin Olson
Firm/Agency:	ECDC
Fax Number:	435-888-0407
From:	Kent Staheli
HA&L Project No.:	113.30.106



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes



Approximate Vertical Scale 1" = 8'

See Figure 6 for Legend and Notes

LEGEND:

Topsoil;

Lean Clay (CL); interlayered with sandy silt, stiff to very stiff, slightly moist to moist, brownish gray.

Silty Clay (CL-ML); sandy, medium to soft, wet, gray.

Sand (SM); silty, occassional lean clay layers, loose to dense, moist to wet, gray to grayish brown.

Gravel (GM/GC); sandy, silty and clayey, occassional cobble and boulders, medium to very dense, moist, brownish gray.

Gray Limestone

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates disturbed sample taken.

Indicates slotted 1 ½ inch PVC pipe installed in the boring to the depth shown.

0 Indicates the depth to free water and the number of days after drilling the measurement was taken.

Indicates screened portion of monitoring well. Screen slots 0.010 inches.

Indicates solid 2" diameter PVC pipe.

Indicates annular space backfilled with Portland Cement Concrete.

Indicates annular space backfilled with bentonite.

Indicates annular space backfilled with sand.

NOTES:

1. Borings were drilled on October 13, 14, 15, 18, 20, 21, 22, 25, 26, 27, 28 and 29, 2004 with 8-inch diameter hollow-stem auger and 3.5 inch tri-cone bit with air circulation.
2. Locations of borings were provided by civil engineer.
3. Elevations of borings were measured by civil engineer.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.
7. Monitor wells were completed with a 4 inch square steel locking cover set in a 2 foot square concrete slab. The 2-inch diameter PVC pipe protected by the well cover extends to approximately 3 feet above the ground surface.
8. WC = Water Content (%);
   DD = Dry Density (pcf);
   +4 = Percent Retained on No. 4 Sieve;
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   NP = Non Plastic

The Carel Corporation

Providing Environmental, Ground-Water and Waste Management Services

August 22, 2005
Project No.: 05-04-09

Mr. Dennis Downs, Executive Secretary
Utah Department of Environmental Quality (UDEQ)
Division of Solid and Hazardous Waste
288 North 1460 West
P.O. Box 144880
Salt Lake City, Utah 84114-4880

RE: Revised Pages for the Groundwater Sampling and Analysis Plan (GWSAP), Wasatch Regional Landfill

Dear Mr. Downs:

Following the August 18, 2005 submittal of the revised GWSAP for the Wasatch Regional Landfill, the UDEQ discovered a few inadvertent errors or omissions in Appendices B and D of the GWSAP. Appropriate revisions have been made to the incorrect pages. On behalf of Wasatch Regional Landfill, we are pleased to provide two copies of replacement pages for the facility GWSAP.

We trust this information is acceptable to you. Please feel free to call me with any questions you may have.

Sincerely,
THE CAREL CORPORATION

Steven Wimmer

Steven J. Wimmer
Geologist

Kevin T. Carel

Kevin T. Carel, P.G.
President

cc: Darin Olson, Allied Waste Industries

RECOMMENDED CONTAINERIZATION AND PRESERVATION OF SAMPLES

Measurement	Volume (mL)	Container$_a$	Preservative	Holding Times	Reference
Physical Properties					
Specific Cond. (Field)	100	P,G	None	Det. on Site	1
Specific Cond. (Lab)	100	P,G	Cool, 4 °C	28 Days	1
pH (Field)	50	P,G	None	Det. on Site	1,2
pH (Lab)	50	P,G	None	24 Hrs	1,2
Temperature	1000	P,G	None	Det. On Site	1
Turbidity	100	P,G	None	Det. On Site	1

Measurement	Volume (mL)	Container$_a$	Preservative	Holding Times	Reference
Inorganics, Non-Metallics					
Carbonate/Bicarbonate	200	P,G	Cool, 4 °C	14 days	1
Chloride	200	P,G	None	28 Days	1,2
Nitrate plus Nitrite	200	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	1,2
COD	50	P,G	H_2SO_4 to pH <2	28 days	1
Sulfate	100	P,G	Cool, 4 °C	28 days	1,2
Ammonia as Nitrogen	1000	P,G	Cool, 4 °C H_2SO_4 to pH <2	28 days	2,3
Total Dissolved Solids (TDS)	500	P,G	Cool, 4 °C	7 days	2,3
Total Organic Carbon (TOC)	250	P,G	Cool, 4 °C HCL or H_2SO_4 to pH <2	28 days	2,3

The Sen's Slope estimator portion of the combined method provides an estimate of the true slope. The method is a non-parametric procedure not greatly affected by gross data errors or outliers, and can be computed when data are missing.

2.2 Statistical Evaluation of Volatile Organic Compounds

Volatile organic compounds (VOCs) will be routinely monitored during the detection monitoring program. The statistical limit for VOCs detected in wells under detection monitoring will be set equal to the laboratory reporting limit (RL). RLs are provided in Table 1 of the facility's Groundwater Sampling and Analysis Plan (GWSAP). As with the prediction limit statistical method, VOC detections will not be considered statistically significant unless confirmed by verification resampling. Verification resampling procedures are provided in Section 2.3 and in the GWSAP.

2.3 Verification Resampling

Results for constituents that exceed statistical limits will not be considered statistically significant unless they are confirmed through verification resampling.

If a statistically significant change (SSC) from background of any tested constituent at any monitor well has occurred (i.e. is confirmed) and there is reasonable cause that a source other than the landfill exists, then a report will be submitted documenting the source as per Section 5.1 of the GWSAP and UAC R315-308-2 (10)(c). Otherwise, assessment monitoring will be implemented in accordance with Section 5.1 of the GWSAP and UDEQ regulations.

3 ASSESSMENT MONITORING STATISTICAL ANALYSIS

For assessment wells, constituents exceeding detection monitoring statistical limits and that have a groundwater protection standard (GWPS) established by the USEPA or the UDEQ, and/or any VOC detections will be statistically compared to GWPS using one-sided 95-percent lower confidence limits (LCL). Evaluations are conducted per Gibbons and Coleman (2001). The method constructs a normal confidence interval on the mean concentration of a constituent incorporating, at a minimum, the four most recent semi-annual measurements. A separate interval is constructed for each constituent of interest in each well of interest. A confidence interval is generally used when downgradient samples are being compared to a Groundwater Protection Standard (GWPS). A flow chart depicting the decision making process during the analysis is provided as Figure E-3.

The lower 95-percent confidence limit on the mean will be compared to a GWPS to decide initially whether the mean concentration of a constituent of interest has exceeded a GWPS. If the lower 95-percent confidence limit on the mean exceeds the GWPS then there is statistically significant evidence that the mean concentration of that constituent exceeds the GWPS. Upper 95-percent confidence limit analyses may be applied to constituents in which it's 95 percent LCL has exceeded a GWPS. If the upper 95-percent confidence limit on the mean occurs lower that the GWPS then there is statistically significant evidence that the mean concentration of that constituent has returned to less than the GWPS.

3.1 Assumptions

The sample data used to construct the limits must be normally or transformed-normally distributed. In the case of a transformed-normal distribution, the confidence limit must be constructed on the transformed sample concentration values. In addition to the limit construction, the comparison must be made to the transformed GWPS value. When none of the transformed models can be justified, a nonparametric version of each limit may be utilized.

The Carel Corporation

Providing Environmental, Ground-Water and Waste Management Services

June 26, 2006
Project No: 06-06-32

Mr. Dennis Downs, Executive Secretary
Utah Department of Environmental Quality (UDEQ)
Division of Solid and Hazardous Waste
288 North 1460 West
P.O. Box 144880
Salt Lake City, Utah 84114-4880

Re: Groundwater Sampling and Analysis Plan (GWSAP) - Table 1 Revision; Wasatch Regional Landfill; Tooele County, Utah

Dear Mr. Downs:

Wasatch
On behalf of the ~~Washington~~ County Landfill, we are including a revised GWSAP Table 1 replacement page. Per a UDEQ request, a revised GWSAP Table 1 replacement page was submitted on March 10, 2006. The UDEQ requested the change because of an error on the CAS number for trans-1,3-dichloropropene which was subsequently corrected. However, the CAS number was inadvertently corrected on an older version of the GWSAP Table 1. The CAS number has been corrected on the final version of the GWSAP Table 1 (completed in August 2005) and the revised replacement page is included in Attachment 1 of this letter. Please discard the replacement page amended in March 2006 and substitute with the replacement page attached to this letter.

We trust that this information is acceptable to you. Two copies of this document are provided for your use and distribution. Please call if you have any questions.

Sincerely,
THE CAREL CORPORATION

Steven Wimmer

Steven J. Wimmer
Geologist

Kevin T. Carel

Kevin T. Carel, P.G.
President

Attachment 1 – GWSAP Table 1 – Replacement Page

cc: Darin Olson – Allied Waste Industries

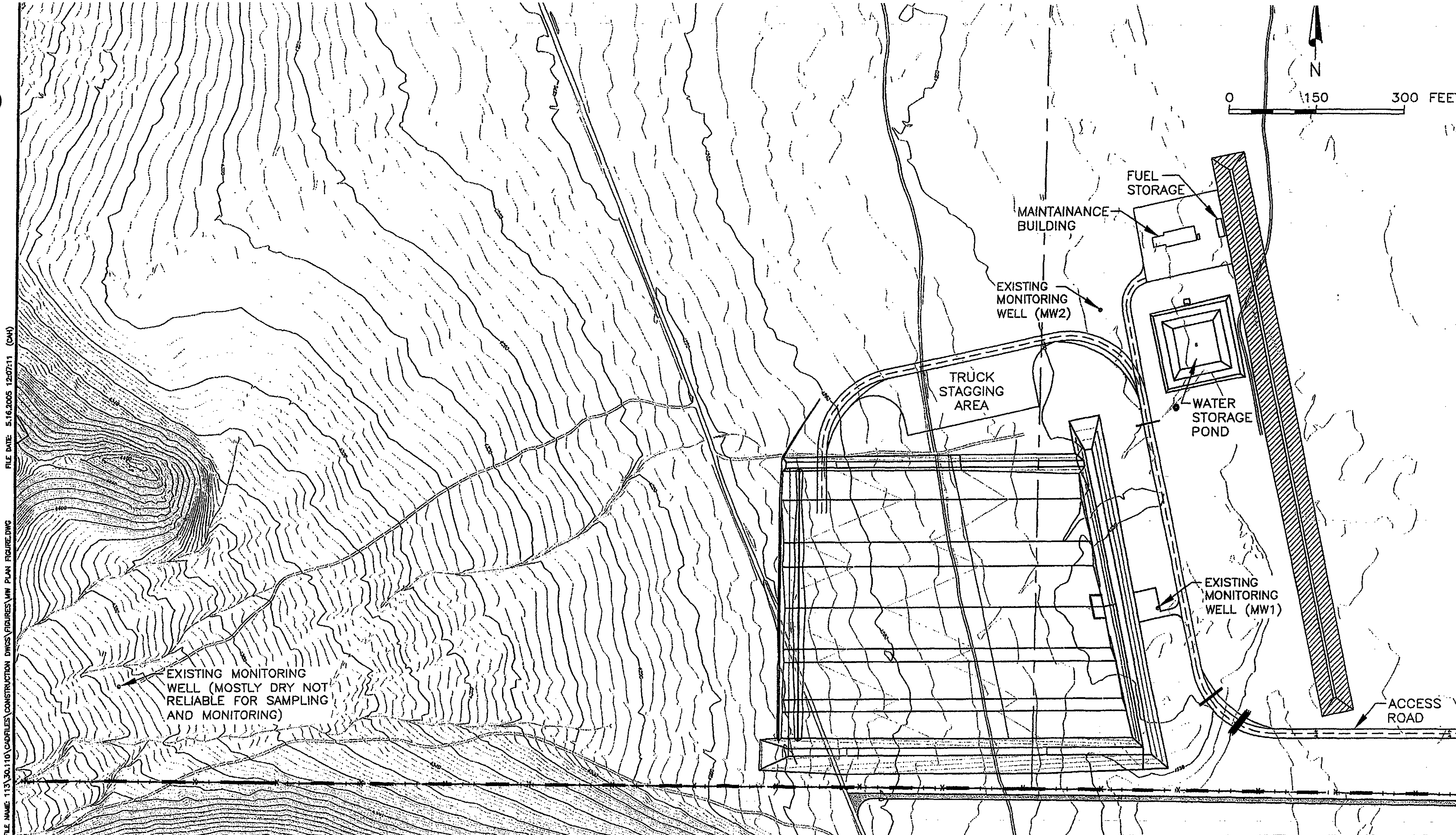
ATTACHMENT 1

GWSAP Table 1 Replacement Page

Table 1 (Continued)

Heavy Metals	CAS	Method[1]	RL[2] (mg/L)
Vanadium	7440-62-2	6010 or 7911	0.02
Zinc	7440-66-6	6010 or 6020	0.01

Volatile Organic Compounds	CAS	Method[1]	RL[2] (µg/L)
Acetone	67-64-1	8260B	10
Acrylonitrile	107-13-1	8260B	50
Benzene	71-43-2	8260B	4
Bromochloromethane	74-97-5	8260B	4
Bromodichloromethane	75-27-4	8260B	4
Bromoform (tribromomethane)	75-25-2	8260B	4
Carbon disulfide	75-15-0	8260B	4
Carbon tetrachloride	56-23-5	8260B	4
Chlorobenzene	108-90-7	8260B	4
Chloroethane (ethyl chloride)	75-00-3	8260B	8
Chloroform (trichloromethane)	67-66-3	8260B	4
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8260B	4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8260B	0.2
1,2-Dibromoethane (ethylene dibromide, EDB)	106-93-4	8260B	0.05
o-Dichlorobenzene (1,2-dichlorobenzene)	95-50-1	8260B	4
p-Dichlorobenzene (1,4 dichlorobenzene)	106-46-7	8260B	4
trans-1,4-Dichloro-2-butene	110-57-6	8260B	4
1,1-Dichloroethane (ethylidene chloride)	75-34-3	8260B	4
1,2-Dichloroethane (ethylene dichloride)	107-06-2	8260B	4
1,1-Dichloroethylene (1,1-dichloroethene)	75-35-4	8260B	4
cis-1,2-Dichloroethylene (1,1-dichloroethene)	156-59-2	8260B	4
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	156-60-5	8260B	4
1,2-Dichloropropane (propylene dichloride)	78-87-5	8260B	4
cis-1,3-dichloropropene	10061-01-5	8260B	2
trans-1,3-dichloropropene	10061-02-6	8260B	2



HANSEN ALLEN & LUCE INC ENGINEERS

WASATCH REGIONAL LANDFILL, INC.

PHASE 1A CONSTRUCTION MONITORING WELL PLAN

FIGURE 1

APPENDIX 13.8
Landfill Gas Monitoring and Control Plan

APPENDIX 13-8

Landfill Gas Monitoring Plan

Landfill Gas Monitoring Plan

Introduction

The landfill gas monitoring plan was developed in accordance with Utah Administrative Code (R315-303-2). Wasatch Regional will not allow concentrations of explosive gases generated by the landfill to exceed twenty five percent of the lower explosive limit, (LEL) for explosive gasses in any facility structures, excluding any gas control or recovery system devices, and one hundred percent of the lower explosive limit for gases at the property boundary. Monitoring will be accomplished by using a hand held device which measure % LEL.

Methane gas monitoring will be preformed quarterly at the facility structures and the property boundary near the existing cell units. Quarterly monitoring will be preformed at the following locations:

1. West corner of scale house
2. Inside the scale house
3. inside the shop
4. Inside the office
5. Southwest property line
6. Southwest corner of the landfill
7. Southeast property line corner
8. Northeast fence line corner
9. Northwest fence line corner

The attached form will be used to document quarterly monitoring.

Facility monitoring will consist of a two-step process: an internal action level and regulatory action level. The internal action level is set at one half the regulatory limit, or 12% of the LEL in structures and 50% of the LEL at the property boundaries. If a monitoring event exceeds the internal action limit, facility management will be notified and a second monitoring event will be immediately scheduled. The second monitoring event results will be compared to the regulatory action limits. If the results exceed the action limits steps will be immediately take to protect human health and the environment. The Division of Solid and Hazardous Waste will be notified and an investigation into the cause of the exceedence will follow. Once the investigation is complete a remediation plan will be developed and implemented.

Wasatch Regional Landfill Gas Monitoring Form

	Q1		Q2		Q3		Q4	
Location	Date	% LEL	Date	% LEL	Date	% LEL	Date	% LEL
West corner of the scale								
Inside of the scale house								
Inside the water purification equipment building								
Inside the shop								
Inside the office								
Southwest property line corner								
Southwest corner of the existing landfill cell unit								
Southeast property line corner								
Northeast fence line corner								
Northwest fence line corner								

Note: Tests performed, Operations Manager, with an Industrial Scientific Corporation LEL monitor, model M40.

APPENDIX 13.9
Closure and Post-Closure Plans

APPENDIX 13-9

Closure and Post Closure Care Plan

Closure Plan

Closure Plan

This Closure Plan was developed in accordance with the Utah Administrative Code (R315-310-3). Closure of the Wasatch Regional Solid Waste Landfill will be completed in accordance with this plan. Closure activities will be performed in such a manner as to accomplish the following goals:

- Minimize the need for further maintenance;
- Minimize or eliminate threats to human health and the environment from escape of solid waste constituents such as: leachate, landfill gases, contaminated run-off or waste decomposition products to the ground, groundwater, surface water, or the atmosphere and;
- Adequately prepare the facility for the post-closure period.

This Closure Plan and any future modifications or changes to this plan will be maintained with the landfill's operating record.

Elements of Closure

Prior to initiating any closure activities, a closure design and QA/QC plan will be submitted to the Executive Secretary for review and approval of all proposed activities. Closure activities will occur in phases. Each phase will vary in size. Final cover construction will be implemented once a subject area is at final grade and the size of the area is large enough to warrant closure activities.

Closure may include final grading and contouring, seeding or placement of stone mulch. Storm water design and control will also be part of closure activities.

Closure Schedule

It is anticipated closure may occur every 8 to 10 years and cover 30 to 35 acres.

Wasatch Regional Landfill will notify the Executive Secretary of the intent to implement the closure plan at least 60 days prior to closure activities. This notification will provide details on the amount of acres to be closed and how the final cover will be constructed.

Once construction has begun, Wasatch will complete closure activities within 180 constructions days. Following the completion of final closure activities, Wasatch will submit within 90 days to the Executive Secretary a set of as-built drawings of final closure construction signed by a professional engineer registered in the State of Utah. Wasatch will also provide certification of the compliance of each phase of closure construction with the approved closure plan. A representative of Wasatch and a professional engineer registered in the State of Utah will sign the certification.

Closure Design

The current final cover design concept and engineering report includes graded intermediate soil cover material, 30 inches of an approved alternative soil cover. Top soil followed by seeding or a stone mulch for erosion control may be used in the closure design.

Final Inspection

Following the completion of closure activities, a final report will be prepared and certified by an engineer registered in the State of Utah. The report will present laboratory and field test data that support the closure plan and conformance of the final cover system, assure closure activities follow the Utah Solid Waste regulations. The report will also include facility closure plan sheets signed by a professional engineer registered in the state of Utah that represent the final, as-built closure construction and the report will confirm that the plats and statement concerning the location and amount of waste will be recorded on the site title. The owner/operator will file the notarized plat with the county recorder of deeds within 60 days of certification of closure. The Executive Secretary will be notified of the completion of closure activities and arrangements will be made for a final inspection by DEQ.

Once the entire site has been closed and approved by Utah DEQ, the post-closure maintenance plan will be initiated pursuant to the approved Post-Closure Plan.

Post-Closure Care Plan

Post-Closure Care Plan

This Post-Closure Plan has been developed in accordance with UAC R315-302-3, and provides for post-closure care and maintenance of the Wasatch Regional Solid Waste Landfill.

Elements of Post Closure

Post Closure will include maintenance and monitoring of gases, land and water for 30 years or as long as the Executive Secretary determines necessary for the facility to become stabilized and to protect human health and the environment. Post Closure activities will include: leachate management, filling areas of differential settlement, erosion control, storm water management, operating and maintaining a gas collection and control system, groundwater sampling and management, air monitoring and reporting, site security and site management.

Post-closure Schedule

The Post-closure maintenance period will begin immediately following the completion of the closure activities. Post-closure activities will continue for a period of thirty years or a period established by the Executive Secretary. If, during the post-closure period, monitoring activities indicate that the site has stabilized and does not pose a threat to human health or the environment, Wasatch may petition the Executive Secretary for a decrease in the length of the post-closure monitoring period. Following completion of the post-closure monitoring period as established by the Executive Secretary, Wasatch will submit to the Executive Secretary a certification, signed by an authorized representative of Wasatch and a professional engineer registered in the State of Utah, which states why post-closure monitoring activities are no longer necessary. After obtaining final approval from the Executive Secretary, post-closure monitoring activities will be discontinued. Any modifications to the post-closure plan will be submitted to the Executive Secretary for review and approval.

Monitoring

Monitoring activities will include: groundwater, surface water monitoring (if necessary), and leachate collection or treatment systems. Landfill Gas system monitoring will be provided in accordance with a Title V permit and or NSPS regulations.

If continued monitoring at the facility indicates that the waste mass has stabilized and does not pose a threat to human health or the environment, the owner or operator may petition the Executive Secretary for a decrease in the length of the post-closure monitoring period. Records for all monitoring activities will be stored at the Wasatch Regional Solid Waste Management Corporation Headquarters.

Maintenance Activities

During the post-closure period, Wasatch personnel will routinely inspect the final cover and drainage systems. The final cover and drainage system will be examined for the effects of erosion, subsidence, settlement, or other indications that the integrity of the final cover or the effectiveness of the drainage system has been compromised. In addition, all groundwater and landfill gas monitoring equipment will be inspected according to the procedures outlined in the groundwater, landfill gas monitoring plans and manufacturing recommendations. If the inspection indicates that there is a need for repairs, the appropriate sub-contractor will be contacted. Repairs will be completed as soon as possible following each inspection in order to maintain the effectiveness of the drainage and final cover systems. The site perimeter fence will also be inspected.

Planned Use of Property

During the closure period, the site will be seeded; sufficient time will be allowed to establish vegetation.